Integrated Resource Plan

TVA's Environmental & Energy Future

Draft | September 2010

TVA

Tennessee Valley Authority

Foreword

The Tennessee Valley Authority (TVA), a federal agency and the largest public power provider in the United States, has prepared this draft Integrated Resource Plan (IRP), titled *TVA's Environmental and Energy Future*, and is making it available to the public for review and comment. This IRP supports TVA's 2008 Environmental Policy as well as the 2007 Strategic Plan and the mission Congress established for TVA in the TVA Act.

As a federal agency, TVA is subject to the National Environmental Policy Act (NEPA) and is required to consider the potential environmental impacts of its proposed actions. In addition to this draft IRP, TVA has prepared a draft environmental impact statement (EIS).

This IRP establishes a strategic direction and provides TVA with the flexibility to make future decisions in a changing regulatory and economic environment. A broad spectrum of options is evaluated for meeting the TVA system demand over the next 20 years in an efficient, reliable, and environmentally sound manner. The draft IRP considers future power needs and economic conditions as well as other uncertainties, such as future environmental legislation and future commodity prices that will affect the choices TVA makes in meeting the demand on its system.

This IRP is an important evaluation for TVA, its customers and residents living within the Valley region. The IRP reflects TVA's objectives of providing competitive rates to its customers, delivering reliable power and a commitment to environmental stewardship within the Tennessee Valley region. The IRP and EIS not only evaluate the means by which TVA will supply reliable power over the next 20-year period, they also evaluate the impacts of TVA's actions on the economy and environment of the Tennessee Valley region.

The NEPA process provides a structured means of obtaining public input into decision-making. A 45-day public comment period will begin with the publication of the Notice of Availability in the Federal Register of the draft IRP and EIS. During this time, TVA will hold public meetings and solicit public comment. All substantive comments on the IRP and EIS will be addressed.

The breadth of analysis that will be presented in the draft IRP is much broader than will be presented in the final IRP. Following review of public comments, data will be refreshed and additional analyses will be completed. This will allow TVA to present the most up-to-date and accurate information on future power needs and resource options in the final IRP and EIS, which are scheduled for release in spring 2011. In addition, building on the demonstrated value of this IRP's approach, it is anticipated that TVA will begin the next IRP effort by 2015.

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Executive Summary

Overview

The Tennessee Valley Authority's (TVA) Integrated Resource Plan (IRP), entitled TVA's Environmental and Energy Future, is intended to address the demand for power in the Tennessee Valley, the options available for meeting that demand, and the potential environmental, economic and operating impacts of each of these options. It will serve as a roadmap for meeting the energy needs of TVA's customers over the next 20 years and, as such, is being conducted in a structured framework and with the benefit of a significant amount of supporting analysis and stakeholder input.

The IRP will guide TVA in fulfilling the renewed vision adopted by the TVA Board in August 2010—to become one of the nation's leading providers of low cost and cleaner energy by 2020. TVA intends to lead the nation in improving air quality, and in increased nuclear production, and lead the Southeast in increased energy efficiency.

That vision will be accomplished while TVA continues to fulfill the mission Congress established for TVA in the TVA Act. The IRP also will be consistent with TVA's 2008 Environmental Policy as well as its 2007 Strategic Plan.

Unlike integrated resource plans prepared by investor-owned utilities, TVA's IRP goes beyond the question of the least cost portfolio of resources needed to meet long term demand, not only in its extensive public involvement but also in the preparation of an environmental impact statement under NEPA. While TVA's mission and strategy both mandate that TVA provide reliable, low cost power to its customers, it also requires TVA to balance this mandate with several other important objectives, including reducing its environmental impacts and emissions, encouraging economic development within the Valley, promoting technological innovation, and managing the integrated river system on behalf of all of its stakeholders.

The IRP establishes a strategic direction for TVA and provides it with the flexibility to make the right choices in a dynamic, ever-changing regulatory and economic environment. Indeed, the planning environment that confronts TVA at this time remains one of the most challenging in TVA's history. In order to navigate through these challenges in a way that best supports its multiple missions, TVA must ensure that its strategy is robust under any number of possible future scenarios while remaining consistent with a philosophy of making the best possible decisions with all available information. To do so, it is imperative that TVA maintains the ability to respond effectively to planning uncertainties so that shifts in strategy can be implemented in an orderly, anticipatory way, with a clear understanding of how those shifts are likely to impact its stakeholders. When changes in future energy options become necessary, TVA will remain focused on making those choices in a way that ensures they are sound from the perspective of economics, risk, reliability and environmental stewardship.

TVA and its stakeholders have common goals of affordable, clean and reliable electricity. It is TVA's commitment that a long-term resource plan be designed that recognizes the sometimes competing needs of its stakeholders, while also respecting the constraints and trade-offs that can be required to meet these needs. This endeavor is particularly challenging now, given the difficult economic conditions facing the nation, the volatility of fuel prices and construction costs, and the regulatory uncertainty facing the electric utility industry. TVA is confident that this IRP will provide the dialogue, processes, tools and analyses needed to face these challenges in a way that ultimately ensures the successful implementation and execution of its strategic goals in support of its extremely important mission.

Public Participation

Public participation is a significant component of the IRP process. TVA is employing a variety of methods to obtain public input and began the IRP effort by providing the public with a 60-day period in which to comment on the range of topics that a sound IRP would address. During this scoping period, TVA hosted seven public meetings at various locations across the Tennessee Valley region. During these meetings, TVA made available to the public groups of experts on generating technologies (including renewable technologies), energy efficiency, the environment, and other key aspects of its operations. It also explained the ultimate goals of the IRP, and described how the public could become involved and make their comments heard. Approximately 200 people attended these public meetings, with approximately 40 of those attendees providing their comments at those meetings. TVA also received numerous other comments by email as well as through its website that had been created expressly for the IRP effort. TVA also received comments from four federal agencies and 20 state agencies.

To ensure continued public involvement while the IRP analyses were being conducted, TVA formed a Stakeholders Review Group (SRG). This group consists of 16 individuals representing a wide range of interests. Members of the group have been asked to provide TVA their viewpoints with respect to the IRP process, assumptions, analyses and results. TVA has met regularly with the SRG to discuss key results as they are produced and intends to continue to do so until the IRP is finalized. TVA has also held quarterly briefings with the public and the media regarding IRP activities and work. In addition, TVA has released the IRP and associated Environmental Impact Statement in draft form to provide another opportunity for public input and it intends to hold additional public meetings with the express purpose of discussing the draft documents.

Chapter 2 describes the IRP public participation effort in more detail.

Need for Power

As a part of the IRP analysis, TVA must develop a forecast of the need for additional power, usually referred to in the electric utility industry as “demand.” In order to develop this forecast, four basic steps are carried out:

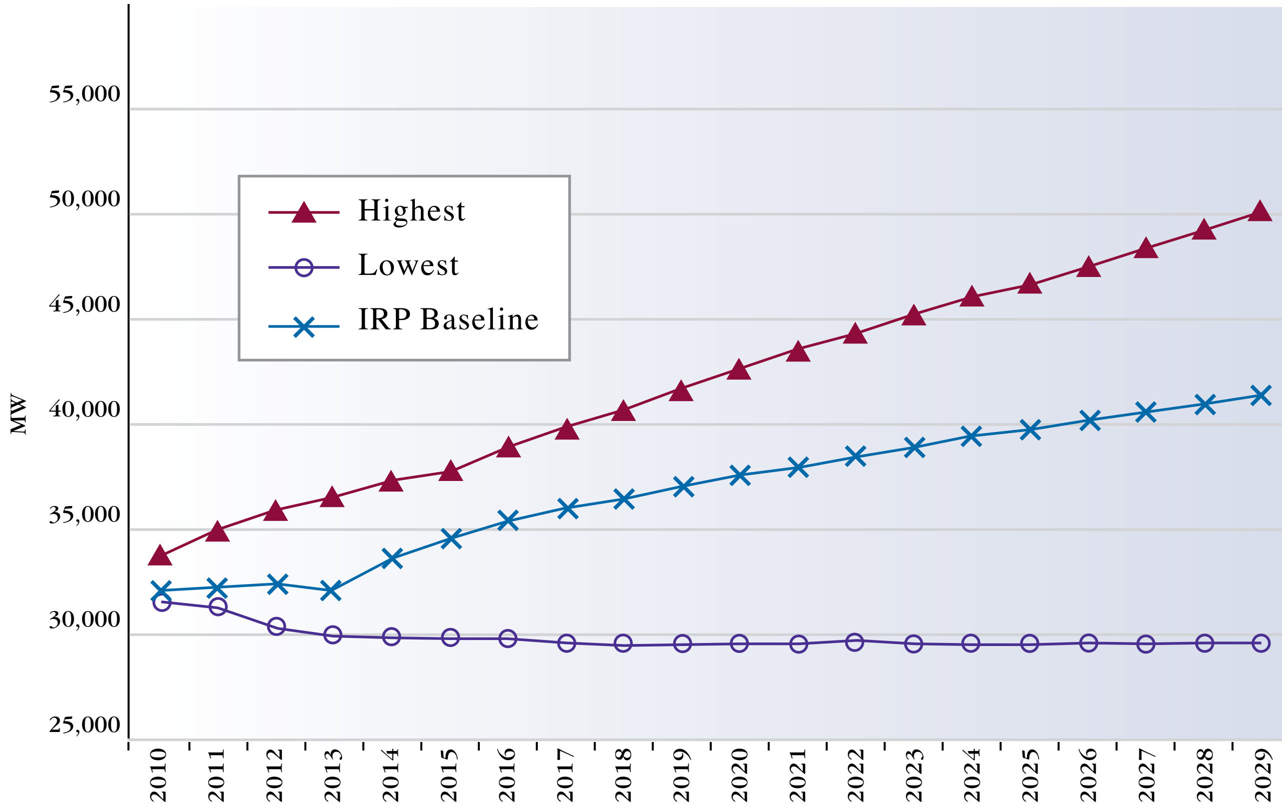
1. **Forecast Demand** – Forecast the demand for electricity (peak demand and energy sales) for the planning horizon over the next 20 years.
2. **Calculate Firm Requirements** – Determine additional generation capacity required by adding to the forecasted demand a planning contingency (sometimes referred to as “reserves”) that allows for unforeseen events, such as demand forecast inaccuracies or unplanned unit outages and other resource limitations.
3. **Identify Existing Resources** – Identify existing generation resources available to meet the forecasted demand over the same period.

4. **Calculate Capacity Gap** – Compare the firm requirements to the amount of existing generation resources, where the difference between the two defines the need for additional resources (sometimes referred to as "capacity gap") over the planning horizon.

TVA expects future economic growth to be lower than historical averages. The effects of the recent recession have been felt across the nation and within the region, and many of these effects will continue to linger for some time, including restricted access to credit (particularly for small businesses, which have been an important source of job growth) and high levels of unemployment. Although employment growth in the manufacturing sector is declining and is expected to remain weak for the near future, opportunities for job growth in other sectors still exist, and TVA expects population growth to return as people migrate to the area to take advantage of these opportunities.

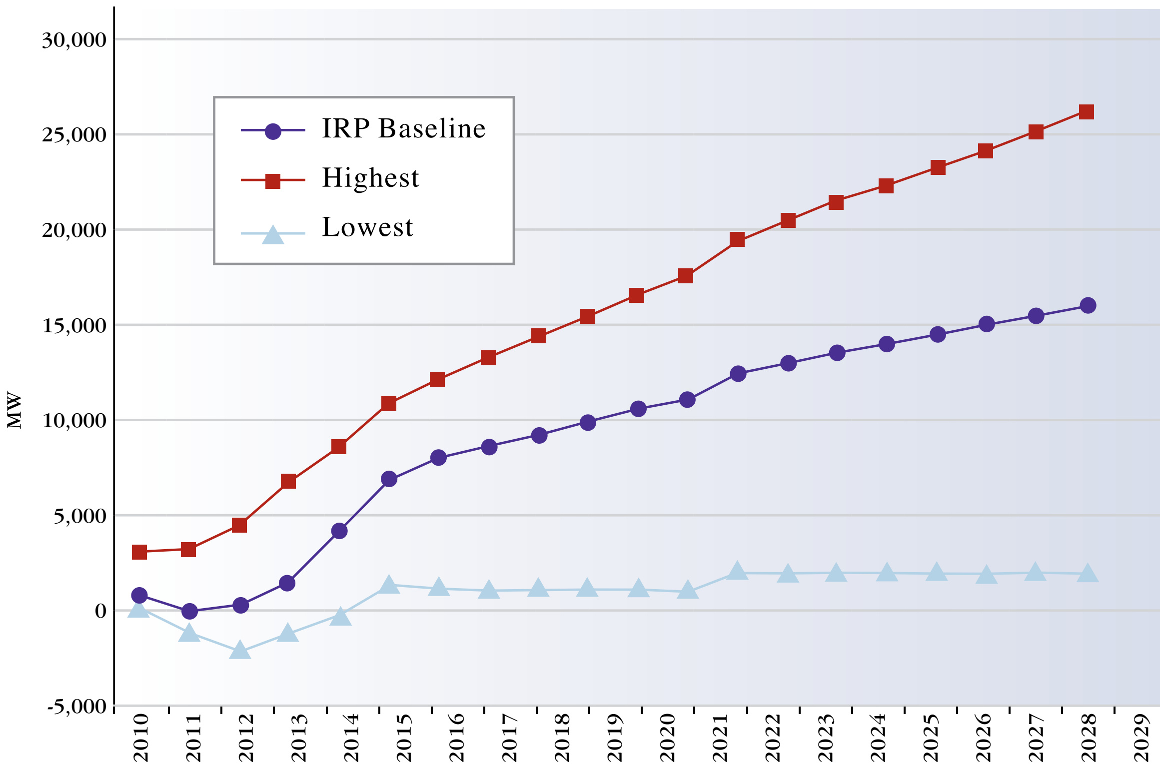
The result is that economic recovery, coupled with population growth and other factors, is expected to lead to continued growth in future power needs, although this growth is expected to occur at a lower rate than historical averages. Figure 1 shows the IRP baseline forecast of peak demand over the 20-year planning horizon. The figure also illustrates the range of load forecasts considered in the IRP with the highest and lowest representing the upper and lower bounds.

Figure 1 – Peak Load Forecast



TVA considered a broad range of forecasts for future demand for electricity in the IRP. For the vast majority of outcomes within this range, it was determined that TVA will require additional power resources to meet growing demand. These resources will include supply options and demand-side options, as well as purchases from others. Figure 2 shows the capacity gap for IRP Baseline forecast over the 20-year planning horizon. The figure also illustrates the capacity gap based on the range of peak loads considered in the IRP. The capacity gaps were developed adding a 15% planning reserve margin to the peak load forecast and subtracting existing resources. Additional detail on the need for power analysis is included in Chapter 3.

Figure 2 – Capacity Gap



Approach

A scenario planning approach is being utilized for the development of the IRP, and TVA is carrying out its analysis in a no-regrets framework. TVA's no-regrets decision making framework defines a process in which all relevant and available information is analyzed in a careful and considered fashion, with significant attention paid to what happens when the world unfolds in a way we are not expecting. In other words, strategic decisions are analyzed not only from the perspective of what we expect to occur in the future, but also from the perspective of what is possible or plausible to occur in the future. Using this framework, decisions made today and in the near future are not overly dependent on the world unfolding exactly as we expect it to today. As a result, the actions taken today are anticipated to provide benefit and value to stakeholders even if the future turns out to be different than predicted.

Scenario planning provides an understanding of how near-term and future decisions will perform under conditions that differ from those expected in the baseline forecast. By analyzing how its decisions perform under stress (higher than expected demand growth, lower than planned fuel prices, or more volatile economic conditions), TVA can learn valuable lessons about formulating and staging those decisions, so that regardless of the world that evolves in the future, TVA's overall level of regret of any one decision is reduced. Similar near-term decisions across multiple scenarios may imply that the decisions embodied in a particular strategy are more robust and/or less "risky," while major differences may imply the possibility of future regrets and greater uncertainty.

Scenarios and planning strategies form the basic building blocks of the IRP analysis. Scenarios portray the range of possible "worlds" that TVA may encounter in the future and are based on a number of factors (uncertainties) that are outside of TVA's control. The scenarios don't attempt to predict the future, only to describe possibilities that we may need to be prepared to encounter. Scenarios are also used to test resource selection and reflect key stakeholder interests.

Examples of factors that may differ between scenarios are economic growth, inflation, fuel prices, demand growth and regulatory environments. Uncertainties vary from scenario to scenario to highlight how decisions would change under different conditions. In addition to the current "world," seven unique scenarios were developed for the IRP based on TVA's baseline forecast early in the development of the IRP as shown below:

- Scenario #1: Economy Recovers Dramatically
- Scenario #2: Environmental Focus is National Priority
- Scenario #3: Prolonged Economic Malaise
- Scenario #4: Game-Changing Technology
- Scenario #5: Energy Independence
- Scenario #6: Carbon Regulation Creates Economic Downturn
- Scenario #7: Current Approach/Baseline

Additional details on the scenarios are included in Chapter 5.

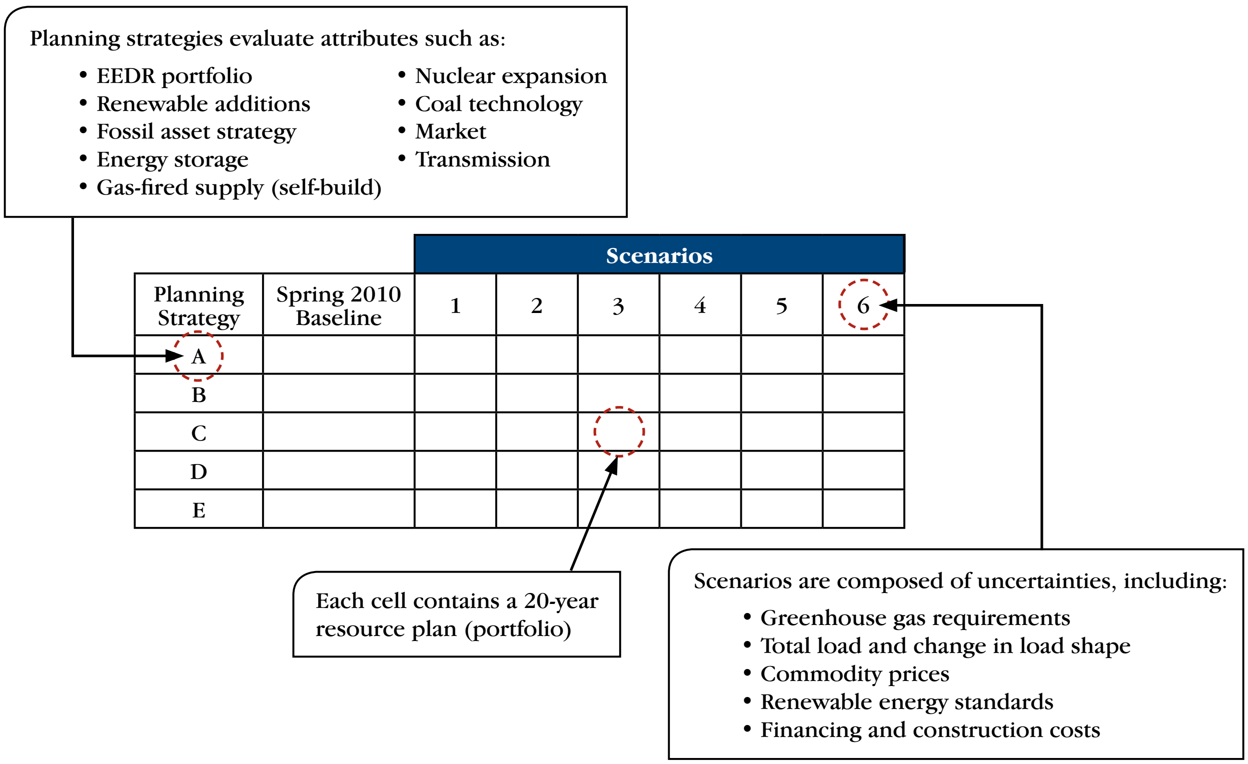
Planning strategies describe a broad range of business options that TVA could adopt and are built upon key decisions that are within TVA's control. Five specific planning strategies were designed for evaluation in the IRP:

- Strategy A: Limited Change in Current Resource Portfolio
- Strategy B: Baseline Resource Portfolio
- Strategy C: Diversity Focused Portfolio
- Strategy D: Nuclear Focused Resource Portfolio
- Strategy E: EEDR and Renewables Focused Portfolio

Additional details on planning strategies are included in Chapter 5.

Each planning strategy is evaluated across the scenarios to test which strategy performs best at meeting customer demand for electricity in that scenario. Figure 3 provides an overview of how scenarios and planning strategies are applied in scenario planning.

Figure 3 – Scenario Planning Matrix



The results produced by evaluating each of the five planning strategies across each of the seven scenarios (six scenarios and Spring 2010 Baseline) will be summarized using a scorecard designed to identify financial, risk and strategic factors that should be considered when selecting a preferred planning strategy. An overview of the scorecard process and its application in the IRP is also included in Chapter 5.

Key Themes from Results

The following key themes have emerged from the draft IRP analysis:

- Nuclear expansion is present in the majority of portfolios.
    - First nuclear unit is added between 2018 and 2022.
    - Nuclear overtakes coal as the leading energy producer.

- The idling/layup of a portion of TVA's fossil capacity are indicated in most portfolios, ranging from 2,000 MW to 7,000 MW of capacity.
- Energy Efficiency and Demand Response (EEDR) as well as renewable generation play an increasingly important role in future resource portfolios.
- Natural gas capacity additions are a viable resource option and a key source of flexibility for TVA.
- The intensity of CO_2, NO_x, SO_2, and Hg emissions decreases in all portfolios.

Preliminary results from the planning strategies have been ranked based on economic cost and risk metrics. A summary of ranking metric results is shown in Figure 4.

Figure 4 – Ranking Metrics

Rank	Planning Strategy	Preliminary Observations
1	C – Diversity Focused Resource Portfolio	- Performs the best against PVRR and risk metrics - Near the median for short-term rates
2	E – EEDR and Renewables Focused Resource Portfolio	- Near the median for short-term rates - Performs near the best for PVRR
3	B – Baseline Plan Resource Portfolio	- Ranks near the median for PVRR, short-term rates and risk
4	D – Nuclear Focused Resource Portfolio	- Ranks below the median for PVRR, rates and risk
5	A – Limited Change in Current Resource Portfolio	- Performs the worst on PVRR and risk - Ranks the best for short-term rates in some scenarios

Definitions of ranking metrics are provided in Chapter 5. Additional detail on the ranking metrics detail for each planning strategy can be found in Chapter 6.

The ranking metrics suggest:

- Diversity Focused Resource Portfolio (Planning Strategy C) and Energy Efficiency and Renewables Focused Resource Portfolio (Planning Strategy E) perform the best relative to the other planning strategies.
- Diversity Focused Resource Portfolio (Planning Strategy C) performs best in more scenarios (5 of 7) than any other strategy.
- The Baseline Plan Resource Portfolio (Planning Strategy B) performs reasonably well.
- The worst performing strategies are Limited Change in Current Resource Portfolio (Planning Strategy A) and Nuclear Focused Resource Portfolio (Planning Strategy D).

Strategic metrics represent considerations beyond cost and risk that are part of identifying the preferred planning strategy. Preliminary results have been used to assess performance against strategic measures of environmental and economic impact. Descriptions of strategic metrics are provided in Chapter 5. Additional detail on strategic metrics for each planning strategy can be found in Chapter 6.

The strategic metrics suggest:

- EEDR and Renewables Focused Resource Portfolio (Planning Strategy E) and Nuclear Focused Resource Portfolio (Planning Strategy D) have the best relative performance on strategic measures.
- Diversity Focused Resource Portfolio (Planning Strategy C) is below the top but above the average.
- The Baseline Plan Resource Portfolio (Planning Strategy B) is below the average.
- Limited Change in Current Resource Portfolio (Planning Strategy A) has the lowest relative performance on strategic metrics.

Highest Ranked Planning Strategies (Draft)

TVA will retain the top three ranked planning strategies for further evaluation. As discussed in the previous section, the top three strategies are:

1. Planning Strategy C – Diversity Focused Resource Portfolio
2. Planning Strategy E – EEDR and Renewables Focused Resource Portfolio
3. Planning Strategy B – Baseline Plan Resource Portfolio

Based on the preliminary results, Planning Strategies C, E and B are the most balanced in terms of cost, financial risk and other strategic considerations. Conversely, Planning Strategy A (Limited Change in Current Resource Portfolio) and Planning Strategy D (Nuclear Focused Portfolio) do not achieve an equivalent balance in performance compared to the ranking and strategic metrics. Therefore, Planning Strategies A and D will be removed from further consideration. Additional detail on the planning strategies retained in the draft IRP is included in Chapter 7.

By retaining three of the five planning strategies, TVA ensures that a broad range of resource options are maintained for consideration in development of the final IRP. Figure 5 summarizes the breadth of potential capacity additions based on the top three planning strategies. The capacity values shown are expressed in terms of dependable capacity at the summer peak.

Ranges represent the minimum and maximum values for each resource type and are not from a single portfolio. Previously approved projects, such as the second unit at Watts Bar Nuclear Plant, are not included in the ranges below:

Figure 5 – Range of Capacity Additions (MW)

Type	Minimum	Maximum
Nuclear	0	4,800
Combustion Turbine	0	7,500
Combined Cycle	0	5,700
IGCC	0	500
Avoided Capacity (EEDR)	1,400	6,000
Renewables	150	1,200
Pumped-Storage	0	850
Coal Reductions	0	4,700

Additional detail on the 12 portfolios used to develop the ranges shown is in Chapter 7.

Additional analysis and sensitivity testing will be completed between the draft and final IRP to identify the preferred planning strategy. In addition, public input received on the draft IRP will be incorporated into the evaluation and considered in the process. Additional detail on public participation in the development of the IRP is included in Chapter 2. A recommendation for the preferred planning strategy will be identified in the final IRP, which is scheduled for completion in the spring of 2011.

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1 Introduction to TVA's Environmental and Energy Future

Electricity lights our homes, schools, hospitals and businesses. It makes our factories run, powers our computers, television sets and entertainment systems, and even provides transportation "fuel" for electric vehicles. Without electricity, many of us would be hotter in the summer and colder in the winter. Affordable, reliable supplies of electricity have become critical to our quality of life, yet very few of us understand the challenges involved in making sure that electricity will be there when it is needed. Reliability of the power supply, affordable and stable rates, as well as the protection of environmental and public health are just a few of the frequently competing objectives that must be considered when determining how to meet future energy needs.

The Tennessee Valley Authority (TVA) is addressing these challenges through its Integrated Resource Plan (IRP) titled *TVA's Environmental and Energy Future*. The IRP is a planning document that outlines and supports TVA's mission and strategy to ensure reliable, low cost power to its customers, while reducing environmental impacts and emissions, encouraging economic development within the Valley, and promoting technological leadership. As such, it is intended to serve as a roadmap for meeting the energy needs of our customers over the next 20 years. It assesses future energy needs and strives to develop a sustainable, flexible approach for meeting them. The IRP establishes strategic direction and flexibility for future decisions in a dynamic, ever-changing regulatory environment.

TVA has renewed its vision to help lead the Tennessee Valley region and the nation toward a cleaner and more secure energy future, relying more on nuclear power and energy efficiency and relying less on coal. The IRP will guide TVA in fulfilling this vision. TVA intends to:

- Lead the nation in improving air quality.
- Lead the nation in increased nuclear production.
- Lead the Southeast in increased energy efficiency.

TVA will accomplish these goals while staying focused on rates, reliability and reputation, and by continuing to fulfill its statutory missions of affordable electricity, economic and agricultural development, environmental stewardship, integrated river system management (navigation, flood control, land management) and technological innovation (including supporting national defense).

As part of this vision, in August 2010, TVA announced the layup of the following nine coal units with a total capacity of about 1,000 MW:

- Two units at Widows Creek in 2011
- Shawnee Unit 10 in 2011 and its evaluation for conversion to a dedicated biomass-fueled unit
- The remaining four older units at Widows Creek within the next four to five years
- Two units at John Sevier within the next four to five years

The IRP also will be consistent with TVA's 2008 Environmental Policy as well as its 2007 Strategic Plan, in accordance with the mission Congress has set for TVA in the TVA Act.

TVA last completed an Integrated Resource Plan, known as *Energy Vision 2020* (EV2020), in 1995. This plan identified a portfolio of short-term actions that would be implemented by 2002 and long-term actions that would be implemented by 2020. At the time it was undertaken, EV2020 was a comprehensive assessment of alternative strategies for meeting future electricity needs based on projected future conditions in the Valley.

This IRP builds from the foundation set forth in EV2020. A dramatically changing environment in terms of the costs of generating technologies—both construction and fuel costs—as well as a very fluid environment with respect to the regulatory and legislative framework within which TVA operates and is expected to operate, coupled with changing customer demand, has prompted TVA to refresh its long term resource plan to increase the likelihood that the decisions taken will be the best ones possible for TVA and its stakeholders. As with EV2020, TVA is also issuing an environmental impact statement (EIS) in association with this new IRP.

1.1 Brief Description of TVA

The Tennessee Valley Authority was established by an act of Congress in 1933. It is a federal agency and corporation, wholly owned by the United States. In addition to being one of the largest generators of electric power in the nation, TVA is also a regional resource development agency, tasked by Congress with improving the quality of life of the residents of the Tennessee Valley region, fostering economic development, and promoting the conservation and wise use of the region's natural resources.

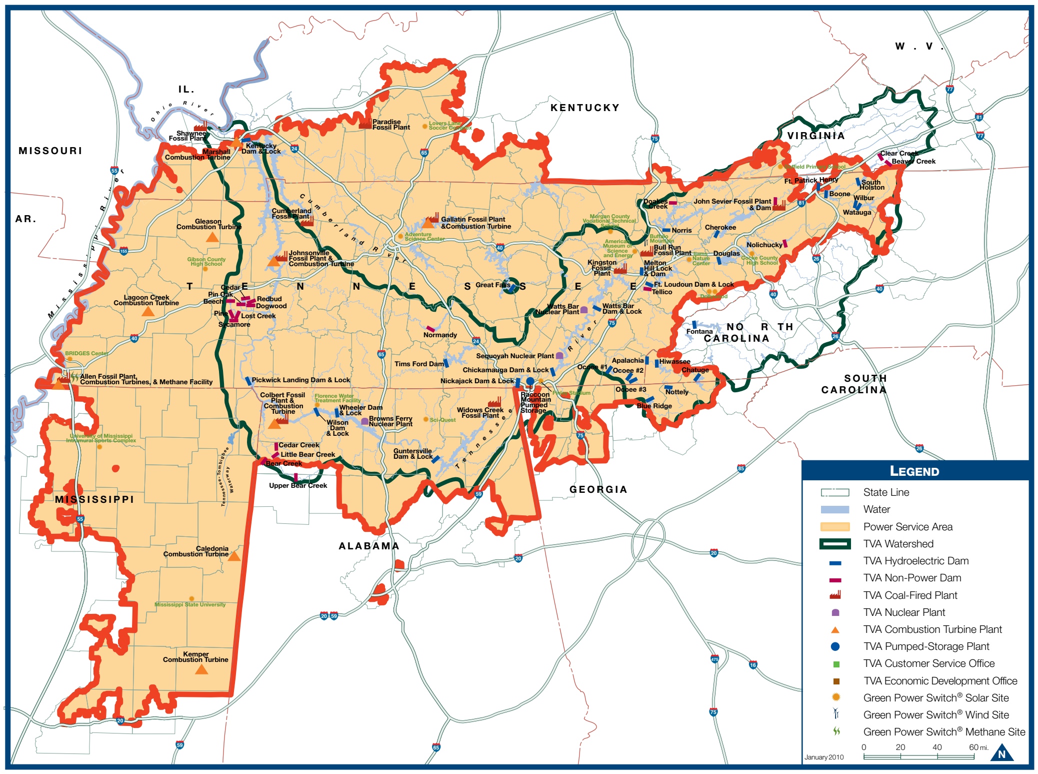
To help achieve this mission, TVA operates the nation's largest public power system. Its power system currently serves more than nine million people in parts of seven southeastern states encompassing 80,000 square miles.

The TVA Act requires the power system to be self-supporting and operated on a non-profit basis. The Act also directs TVA to sell power at rates as low as feasible. TVA receives no appropriations from Congress for its activities and the services it provides to the public. A nine-member Board of Directors sets policy and strategy for TVA. TVA Directors are nominated by the President and confirmed by the U.S. Senate to serve five-year terms.

1.2 TVA Region and Power System

TVA is the largest public power producer in the United States and is a primary wholesaler of electricity. Its electrical system serves nine million people in an 80,000-square-mile area spanning seven states, including most of Tennessee and parts of Alabama, Georgia, Kentucky, Mississippi, North Carolina and Virginia.

Figure 1-1 – TVA Service Territory



The all-time record peak demand for electricity in TVA's service territory was set on August 16, 2007, at 33,482 megawatts. To meet this demand reliably, TVA operates a diversified generating system with a dependable generating capacity of approximately 37,000 (MW). This generating capacity is made up of six nuclear reactors at three plant sites, two natural gas-fired combined cycle power plants, 11 coal-fired power plants, nine combustion-turbine plants, 29 hydroelectric dams, two diesel generator plants, a pumped-storage facility, a wind farm, a methane-gas co-firing facility, and several small photovoltaic facilities. A portion of this capacity is also provided by third-party operators who sell their output to TVA under long-term power purchase agreements. Electricity is transmitted to 155 local distributors and 56 large industrial and federal installations through a network of approximately 16,000 miles of transmission lines; 487 substations, switchyards and switching stations; and 1,020 individual customer connection points.

TVA delivers electricity to three main customer groups: distributors, directly served customers and off-system customers. Distributors of TVA power, of which there are 155, account for about 81% of total TVA sales and 87% of total revenue. These distributors, which are primarily municipally-operated utilities and distribution cooperatives, resell TVA power to retail consumers metered and billed by the distributors themselves. Municipal utilities make up the largest block of TVA customers. Cooperatives are customer-owned companies, many of which were originally formed to bring electricity to the farthest reaches of the TVA region. Another 19% of total sales, accounting for 13% of TVA's total revenue, are to approximately 50 large industrial customers and six federal installations that buy TVA power directly. Off-system customers buy power from TVA on the interchange market and make up the remainder of TVA's sales and revenue.

TVA Power Contracts govern the relationships between TVA and the 155 distributors of TVA power, including the rate structure under which that power is sold. The contracts provide for a distributor's full requirements, meaning TVA agrees to generate and deliver enough electricity to meet the distributor's full electric load, including reserves, both now and in the future. To meet this contractual commitment reliably, TVA must have a combination of its own generating resources, and contractual rights (through power purchase agreements) to the resources of independent power producers, as well as maintain a highly reliable transmission system to deliver those resources when needed.

1.3 Purpose and Need for Integrated Resource Planning

1.3.1 The Challenge

The size of TVA's power system, and its large influence on the Tennessee Valley region's economy, environment and resources, make integrated resource planning especially important for TVA and the public it serves. The competitive success of businesses and industries in the Valley, as well as the ability to sustain and improve the quality of life for millions of Valley residents, are potentially impacted by the decisions that will be guided by the final result of the IRP process.

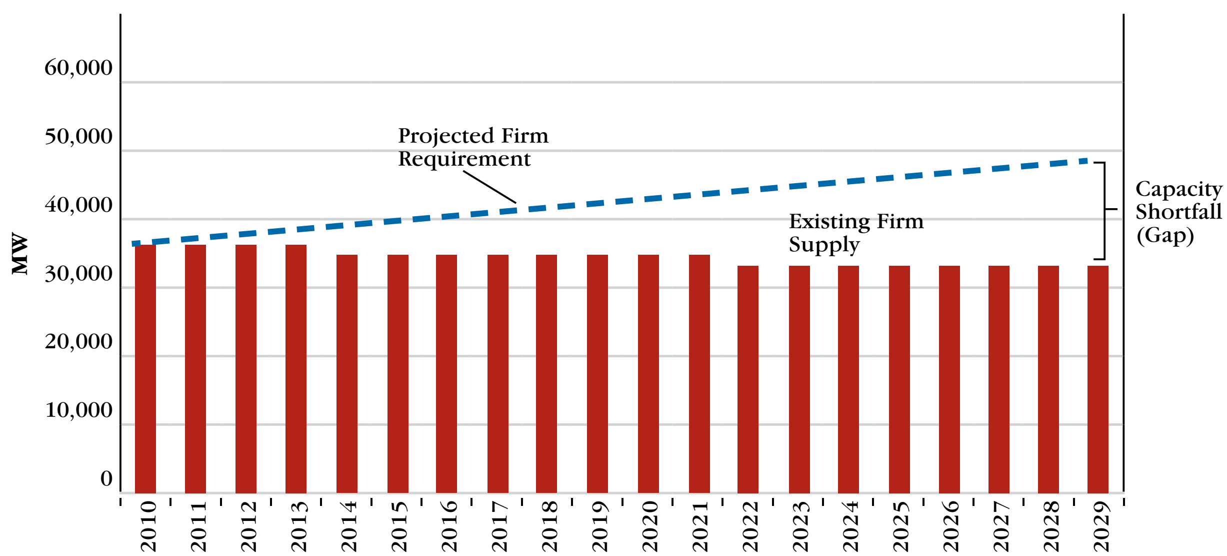
Because electricity cannot yet be stored economically in meaningful quantities, the supply of electricity must meet the demand for electricity at all times. This means that electricity providers like TVA must predict what the demand for electricity will be in the future, and then take steps, including the construction of generating capacity or the procurement of purchased power, in order to increase the likelihood it will be able to effectively meet this forecast demand. Given the long lead times involved in planning, permitting and building generating facilities, these forecasts are often 10 to 20 years in length.

Transmission expansion also involves long lead times and is a vital component in meeting forecasted demand. Expansion is necessary to enable a number of system modifications, including delivery of new or existing generating capacity to areas of increased demand; retirement of older, relatively higher emission generators; and increased energy import, particularly of renewable energy which tends to be located distant from TVA's service area. Transmission is usually a very cost-effective means of providing power system flexibility, historically costing TVA on the order of 10% of the amount of associated generation additions. However, potential effects on water, vegetation, wildlife and other environmental concerns make this an option that must be evaluated carefully.

In addition to building generating facilities, or acquiring the output of independently owned facilities through long term contracts, TVA can also meet demand through the deployment of programs designed to encourage energy conservation and demand reduction. These activities have associated uncertainty and risk, and designing an effective strategy, and then executing on that strategy, is one of the inherent challenges of resource planning for all electric utilities, including TVA.

TVA is undertaking this IRP process at an especially critical time. Nationally, there appears to be consensus that energy should be produced in cleaner, more environmentally friendly ways—a direction that TVA had already embraced as evidenced by the goals established in its 2008 Environmental Policy.

Figure 1-2 – Capacity Shortfall



It must be recognized by all that achieving these goals, while at the same time keeping electricity affordable for all residents of the Tennessee Valley, will be a challenge, particularly given the difficult economic conditions facing the nation and the regulatory uncertainty facing the industry as a whole. However, TVA is confident it can successfully meet that challenge by working with our stakeholders to design a long-term resource plan that explicitly recognizes the trade-offs that must be made to achieve our common goals of affordable, clean and reliable electricity.

1.3.2 The Role of the Integrated Resource Plan

The IRP will act as a long-term guide that evaluates reliable, cost-effective resource options for meeting future customer demand for electricity subject to economic and operating constraints. A wide variety of resource options (both supply- and demand-side) are considered in order to meet customer demand. These options include conventional power plants, renewable energy sources, energy efficiency, demand response, and power purchases.

The IRP is tasked with meeting future customer demand by identifying any future shortfall in capacity and finding the optimum mix of resources to fill this shortfall. The capacity shortfall (gap) is the difference between the projected firm requirements and existing firm supply. An example is shown in the figure above (Figure 1-1). Existing firm supply includes all existing generating resources as well as approved projects and power purchase agreements. Projected firm requirements include forecasted peak demand adjusted for interruptible loads and a planning reserve margin. The objective of an IRP is to identify a low cost option to close the gap between existing firm supply and projected firm requirement that is also balanced enough to reduce risk and enhance flexibility.

Given the complexity involved in all of these activities, including uncertainty in the forecasts themselves and a constantly changing business and regulatory environment, integrated resource planning is a crucial element of the planning process. Integrated resource planning is built on a foundation of comprehensive, holistic and risk aware analysis. Whereas traditional methods of resource planning focus primarily on generating projects only (i.e. supply), integrated resource planning accounts for demand-side options, which can serve as a very effective offset to growing customer demand.

The integrated approach considers a broad spectrum of feasible supply- and demand-side options and assesses them against a common set of planning objectives and criteria, including cost, risk, rate impact and environmental impact. The Integrated approach is also characterized by its participatory and transparent approach, where stakeholders are actively engaged in developing the plan.

In short, the integrated resource planning approach provides an opportunity for planners, and the stakeholders who will be impacted by decisions made by the planners, to address complex issues in a structured, open and transparent fashion.

1.3.3 Impact of The National Energy Policy Act of 1992

The National Energy Policy Act of 1992 established requirements that TVA is required to meet when it carries out its long term planning activities. The goal of a sound long-term plan is to provide energy services to customers at the lowest total cost over the long run.

TVA's integrated resource planning process goes well beyond conventional least-cost planning employed by most utilities in many important ways. For example, like *Energy Vision 2020*, this IRP evaluates the effects of resource options on the Tennessee Valley's environment and its economic well-being, as well as on future prices of electricity and the financial health of TVA. *TVA's Environmental and Energy Future* reflects the results of customer participation and extensive public involvement, including the preparation of an environmental impact statement under the National Environmental Policy Act, which goes well beyond the types of environmental assessments that TVA's peer utilities are traditionally required to carry out as part of their own resource planning activities.

TVA has integrated the components of this programmatic environmental impact statement into the overall integrated resource planning process and preferred plan to develop an environmentally-informed resource plan that focuses on reducing costs and risk, while also improving TVA's environmental footprint. A programmatic level environmental impact statement was developed as opposed to a project or site-specific environmental impact statement because of the broad strategic nature of integrated resource planning.

1.4 TVA's IRP Goals

As discussed earlier in the Introduction, the primary goal of the Integrated Resource Plan is to help ensure that TVA can meet the demand for electricity on its system in a cost-effective, reliable manner with due regard for protection of public health and the environment. TVA will strive to meet these goals by adopting a *preferred* strategy that it believes accounts for the expectations of the majority of our stakeholders, while still supporting its multi-faceted mission of providing low cost, reliable power to its customers, protecting the environmental resources of the Valley, and serving as a catalyst for economic development in the TVA region. The evaluation of the strategic alternatives considered as part of the IRP involves extensive computer modeling, analysis, review and input from stakeholders and the public, in addition to significant internal evaluation and discussions with TVA's Board of Directors. Constraints, trade-offs and corporate strategic objectives are all considered as the different combinations of certain strategies and uncertain futures are analyzed and weighted. The expectation is that there will not be a single correct answer, but rather a robust plan that best balances competing objectives while reducing costs and risks and retaining the flexibility to respond to future risks and opportunities as they unfold.

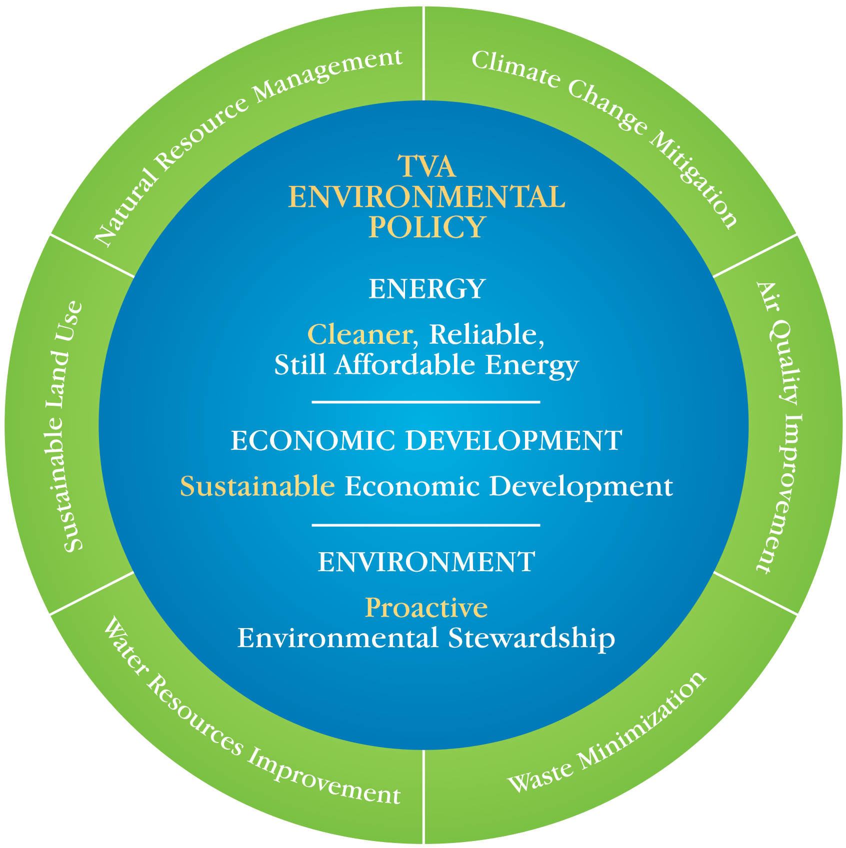
A primary goal of the IRP is to engage the public in a transparent process that solicits and ensures public input, while also educating participants on the constraints and trade-offs required to produce a plan of this magnitude. The end result should be a process that all parties involved feel is fair and representative. Input received from the general public and stakeholders is a key part of the IRP process and associated EIS that assists TVA in choosing an adequate resource plan for TVA, its customers, stakeholders and the Valley residents it serves. TVA captures this feedback through outlets such as public briefings, phone surveys, and through its Internet presence at www.tva.gov/irp. A key aspect of public participation is the Stakeholder Review Group, which engaged in development of the IRP throughout the entire process through scheduled working sessions with TVA staff. For a more detailed description of public participation within the IRP process, see Chapter 2.

1.5 TVA's IRP Objectives

As previously mentioned, TVA has a multi-faceted mission. The objectives of the IRP are illustrated well in Figure 1-3 on the following page. The ultimate goal of *TVA's Environmental and Energy Future* is to produce a robust resource plan that TVA can follow to produce competitive services to our ratepayers. The IRP's definition of competitiveness goes beyond being a low cost electricity producer; it also means that TVA must be competitive in the quality and value of the electric services it provides. Furthermore, it is measured in terms of TVA's contribution to economic development in the region and the region's environmental quality.

In addition, TVA has modified the typical integrated resource planning process to seek more opportunities for public involvement and improved transparency. When the IRP is completed, TVA wants our stakeholders to feel that the processes were reasonable and that TVA listened to their input.

Figure 1-3 – TVA Environmental Policy



1.6 The IRP Process

The IRP process consists of six distinct steps:

1. Develop Scope
2. Develop Inputs and Framework
3. Analyze and Evaluate
4. Release Draft IRP and Solicit Public Comment
5. Incorporate Public Comment and Run Sensitivities
6. Identify and Recommend Preferred Strategy

These steps are summarized below and explained in more detail in Chapter 5 – Resource Development Plan and Analysis.

1.6.1 Develop Scope

TVA initiated a public scoping period beginning in June 2009. Public scoping comments addressed a wide range of issues, including the integrated resource planning process, preferences for various types of power generation, increased energy efficiency and demand response (EEDR), and the environmental impacts of TVA's power generation, fuel acquisition, and transmission operations. These comments were crucial in helping the IRP project team identify what the relevant public concerns were with respect to TVA's long term resource planning.

1.6.2 Develop Inputs and Framework

A no-regrets decision making framework is one in which decision makers feel they have analyzed relevant risks, probabilities of certain futures, and the challenges that may be faced adequately so that decisions made have a high likelihood of being sound. In order to facilitate a no-regrets decision framework, TVA is employing a scenario planning approach in development of the draft IRP. Scenario planning provides an understanding of how near-term and future decisions would change under different conditions, which allows for impacts on different courses of action to be analyzed and assessed, and weight given to those actions that may not perform the best in each and every scenario, but perform relatively well in all. Future decisions that produce similar results across different conditions may imply that these decisions provide more predictable outcomes, whereas decisions that result in major differences are less predictable and thus more "risky."

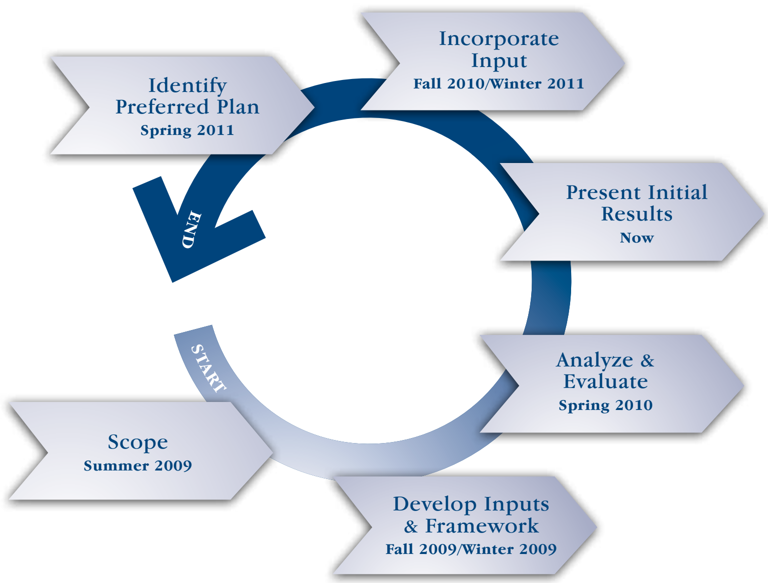
To begin the process, TVA, in collaboration with its stakeholder group, developed a set of resource planning portfolios (or strategies) that would be analyzed within the framework of the IRP. These strategies consisted of different mixes of generating technologies, including renewables and demand-side options, and formed the framework of distinct resource planning strategies that would then be supplemented as needed with other more flexible resources. (As such, the strategies were designed to reflect key decisions that TVA has direct control to make for the intended duration of the IRP planning horizon.) Significant expert input was used to ensure the feasibility of elements of each of the five strategies, each characterized by a different supply- and demand-side resource mix that were developed for testing.

Strategies represent business decisions that TVA has full control over.

In fall 2009, in order to facilitate a process of no-regrets analysis of the strategies developed above, TVA began to develop a series of scenarios that would be used to analyze the outcome of resource planning decision strategies. These scenarios would differ from each other in several key areas, including projected customer demand, future economic conditions, fuel prices, regulatory frameworks and numerous other key drivers. The goal was to identify sets of events, forecasts and other important drivers that TVA could not directly control, but would have a direct impact on TVA's ability to achieve its IRP goals by impacting the resource planning decisions taken within that IRP.

Scenarios represent events that TVA has little or no control over but can have a direct impact on TVA's ability to achieve its goals.

Figure 1-4 – TVA Integrated Resource Planning Process



One way to think of these scenarios is as miniature models of the world. In one model, the economy might stagnate, prices drop and electricity demand stay flat. In another, strong economic recovery could pressure fuel prices, drive interest rates higher, lead to rapid recovery in electricity sales and long term demand growth, and put upwards pressure on the cost of building generating assets. Both scenarios will present dramatically different challenges to any one resource strategy, and the key to sound resource planning is designing a strategy that performs reasonably well, regardless of which scenario most closely captures the actual state of the world in the future.

Seven such scenarios or miniature models of the world were ultimately developed, within which each resource planning strategy was tested for performance.

1.6.3 Analyze and Evaluate

After the inputs, scenarios and strategies were developed, detailed analysis was undertaken of each planning strategy within each one of the scenarios. This phase of the IRP employed industry standard capacity expansion planning and production cost modeling software to develop total cost estimates of each planning strategy in each state of a scenario. Other metrics, including near-term rate impacts, risk and environmental footprint, were also developed using model outputs.

In this manner, the five planning strategies were systematically evaluated within the context of the seven scenarios. In other words, TVA analyzed the hypothetical performance—on a cost, risk and environmental footprint basis—of each strategy on the assumption that the future unfolded in a manner that closely resembled the world specified within each scenario. Ultimately, the development of capacity expansion plans specific to each of the five strategies, for each of the seven scenarios, resulted in a total of 35 unique capacity expansion plans (or “portfolios”), each of which had been optimized to perform well for the specific scenario they had been developed for. Each portfolio represents a long-term, least-cost plan made up of different asset mixes (both supply- and demand-side assets) that could be deployed to meet the power needs of the region.

After all 35 portfolios were developed, each was ranked using selected metrics within the framework of a consistent and standard scorecard. The metrics were chosen based on their importance and centrality to TVA’s mission and included metrics capturing cost, reliability, risk, economic development, environmental stewardship and technology innovation. The ranking is not intended to identify any single strategy as “the best.” Rather, through the process of a consistent analytical ranking exercise, TVA’s Board of Directors and leadership team are provided with information that can be used to help them conduct a trade-off evaluation of decisions pertaining to TVA’s existing generation fleet and available generation options. It also facilitates TVA’s ultimate adoption of a long-term resource planning strategy that will then serve as the foundation for TVA’s near-term business and financial plans.

1.6.4 Release of Draft IRP and Solicitation of Public Comment

The next phase of the IRP process was to present the results to both internal TVA stakeholders and the general public in the form of a draft IRP document and associated EIS. The draft IRP *does not* present a preferred strategy, but rather a number of alternative strategies that TVA is considering. The draft IRP does not include all strategies analyzed. It includes a sampling of unique strategies that represent a broad spectrum of viable options for implementation.

Similar to the scoping period, TVA encourages public comments on the draft IRP and associated EIS. These comments will aid TVA staff in identifying public concerns and interests in the future operation of the TVA power system. The public comment period begins with the Environmental Protection Agency's publication of the Notice of Availability of the draft IRP and Environmental Impact Statement in the Federal Register. During the public comment period, TVA will hold four public meetings to provide the public information about the IRP and to receive public input during the month of October 2010. These meetings will be located at: Bowling Green, Ky.; Olive Branch, Miss.; Knoxville, Tenn.; and Huntsville, Ala. A schedule of the public meetings is posted on the IRP website at www.tva.com/irp.

TVA will address all substantive comments received during the public comment period in the final IRP and its associated EIS, as appropriate.

1.6.5 Incorporate Public Comment and Additional Modeling

After the public comment period closes, all comments submitted will be taken into consideration and addressed in preparation for publishing the final IRP document. Additional modeling to analyze small changes to the strategies or scenarios will be executed based on both public and internal feedback. Key inputs and assumptions will be revised to reflect current conditions, which will lead to an updated analysis and evaluation of results.

1.6.6 Identify and Recommend Preferred Strategy

After considering public comments and updating, revising and conducting additional analyses as appropriate in the IRP and EIS, TVA staff will identify and recommend to the TVA Board a preferred strategy. This strategy will be identified based on a number of key criteria, including cost, risk, environmental impacts and economic implications. No sooner than 30 days after a Notice of Availability of the final EIS is published in the Federal Register, the TVA Board will be asked to approve an IRP strategy. The Board's decision will be described and explained in a Record of Decision.

1.7 IRP Deliverables

1.7.1 Draft and Final IRP Documents

The IRP will be published twice, once as a draft document and again as a final document. The draft IRP will provide a broad look at all the options TVA has considered and the long-term implications of various business strategies. Following a public comment period and associated revisions, the final IRP will recommend a robust, flexible plan that supports TVA's unique mission of *"serving the Valley through energy, environment and economic development."* The preferred strategy will entail an outcome that balances costs, efficiency in electricity generation, reliability, energy efficiency, environmental responsibility and competitive rates for customers.

1.7.2 Draft and Final Environmental Impact Statement

As part of the IRP, TVA has also prepared a draft environmental impact statement in accordance with the National Environmental Policy Act (NEPA) 42 USC §§ 4321 et seq., Council on Environmental Quality (CEQ) regulations for implementing NEPA 40 CFR Parts 1500-1508, and TVA's procedures for implementing NEPA. NEPA requires federal agencies to consider the impact of proposed actions and alternatives on the environment before making decisions with potential environmental impacts. The NEPA EIS process provides a structured means of analyzing competing options and for involving the public in TVA's decision-making processes.

TVA will use the draft environmental impact statement, as well as the analyses in the IRP, to select a resource plan for implementation. The EIS will initially be released in draft form, providing the public the opportunity to comment. After addressing public comments, it will be issued in final form for consideration by the TVA Board.

Chapter 2 – Public Participation

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2 Public Participation

Public participation is a significant component of the IRP process. TVA has purposefully set out to elicit and incorporate a broad range of public input into the development of the IRP to ensure that stakeholder viewpoints, concerns and aspirations have been adequately addressed.

To better facilitate public participation, TVA is disseminating a broad range of information to the public, including information about why TVA is developing an IRP, how the IRP is developed, what the IRP analyses show, and how results will be used to guide decision making for years to come.

There are three principal times during the IRP process in which public participation is actively solicited:

1. Scoping Period
2. Analysis and Evaluation Period
3. Release Draft IRP and Solicit Public Comment Period

2.1 Scoping Period

TVA began the 60-day public scoping period of the IRP on June 15, 2009. In addition to publishing an official notice in the Federal Register, TVA announced the start of the process in newspapers throughout the Valley, media releases, as well as the project website. Key analytical elements such as scenario planning, resource options and evaluation criteria were drawn from public comments during the scoping period.

TVA used two primary techniques to collect public input during the scoping period:

1. Public Meetings
2. Written Comments

2.1.1 Public Meetings

During the scoping period, TVA held seven public meetings across the Tennessee Valley. The meetings were conducted in an informal, open house format to give participants an opportunity to express concerns, ask questions, or provide comments. These meetings, announced in local and regional newspapers and other media, were held in the following cities:

- Monday, July 20, 2009 Nashville, Tenn.
- Tuesday, July 21, 2009 Chattanooga, Tenn.
- Thursday, July 23, 2009 Knoxville, Tenn.
- Tuesday, July 28, 2009 Huntsville, Ala.
- Thursday, July 30, 2009 Hopkinsville, Ky.
- Tuesday, August 4, 2009 Starkville, Miss.
- Thursday, August 6, 2009 Memphis, Tenn.

Attendees included members of the general public, representatives from state agencies and local governments, TVA's congressional delegation representatives, TVA power distributors, non-governmental organizations, and other special interest groups. Exhibits, fact sheets and other materials were shared at each public meeting to provide information about the study and the EIS. TVA subject matter experts attended each meeting to answer questions and discuss issues about the IRP planning process and TVA's power system and programs.

2.1.2 Written Comments

During the scoping period, TVA accepted comments via email, fax, letters, TVA website, public scoping meetings and a scoping questionnaire. During the public scoping meetings, verbal comments were recorded by court reporters, and attendees were able to submit written comments by logging into the IRP website on TVA supplied laptops. In addition to the public meetings, a scoping questionnaire was developed to elicit public opinion on TVA's future generation and efficiency options. At least part of the scoping questionnaire was completed by 845 people, and almost 640 of these respondents answered the write-in questions as well as the multiple-choice questions.

During scoping, including the survey responses, TVA received over 1,000 comments. Sixty-five email comments were received from individuals and organizations and an additional 50 comments were submitted through the TVA website. It is estimated that approximately 200 attended the public scoping meetings, and, of these, 40 submitted comments during those meetings.

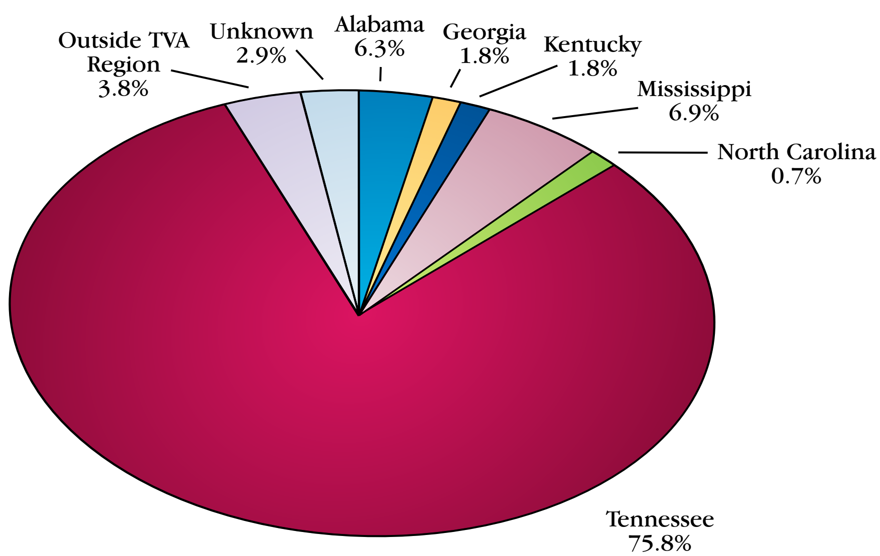
Comments were received from four federal agencies and 20 state agencies representing six of the seven TVA region states. Some of these responses included specific comments, which are incorporated below, while others stated they had no comments but asked to review the draft IRP and associated EIS. Some comments from agencies, organizations and individuals were specific to TVA's natural and cultural resource stewardship activities and were not included in this scoping report because they are the focus of another planning process—the preparation of a TVA Natural Resource Plan and associated EIS.

In total, scoping comments were received from six of the seven TVA region states as well as some states outside the TVA region. Figure 2-1 shows the distribution of scoping comments by geographic area.

2.1.3 Results of the Scoping Process

Many of those completing the scoping questionnaire expressed a willingness to take various measures to reduce their energy use or pay higher rates for cleaner energy. The willingness to undertake some measures increased with the availability of financial incentives. The comment responses provided beneficial insight to some of the public's perception of TVA programs and willingness to invest in certain resource options. However, control questions in the survey indicate that the survey population does not necessarily represent the general public. To ensure a wider representation of opinion, TVA decided to conduct a phone survey of approximately 1,000 individuals across the entire TVA region. The survey is discussed in Section 2.2.3 under the Techniques for Collecting Public Input during the Evaluation and Analysis Period.

Figure 2-1 – Distribution of Scoping Comments by Geographic Area



Other scoping comments addressed a wide range of issues, including the integrated resource planning process; preferences for various types of power generation; increased energy efficiency and demand response; and the environmental impacts of TVA's power generation, fuel acquisition, and transmission operations. Comments on these issues are briefly summarized below, and the scoping comments are listed in more detail in the EIS Scoping report issued in October 2009.

Cost of Electricity

The issue most frequently mentioned in the scoping comments was the cost of electricity. While a large number of the commenters were opposed to any future price increases, a number of those completing the questionnaire expressed a willingness to pay more ($1-$20) per month for TVA to increase generation from non-greenhouse gas emitting sources.

Reliability

Reliability and the ability to meet future demand were also among the most frequently mentioned issues. A number of commenters expressed concern about and/or dissatisfaction with TVA's corporate direction, TVA facility maintenance, and TVA's ability to adapt to future conditions.

The Integrated Resource Planning Process

Several commenters addressed the integrated resource planning process. Their comments recommended that TVA: follow industry standard practices; enter the process without preconceptions about the adequacy of various resource options; be open and transparent throughout the planning process; treat energy efficiency and renewable energy as priority resources; and address the total societal costs and benefits.

Recommended Energy Resource Options

Many scoping comments included general recommendations about TVA's future supply- and demand-side resource options. Common themes in the comments were that TVA's future resource portfolio should avoid or minimize rate increases, minimize or reduce pollution and other environmental impacts, and maximize reliability. The most frequently mentioned generalized resources included increased renewable generation (including wind, solar, locally-sourced biomass and low-impact hydro), decreased coal-fueled generation and increased nuclear generation.

Other comments pertained to decreased nuclear generation, increased energy efficiency and demand response programs, reliance on a diversity of fuel sources, avoidance of uneconomical renewable generation, and the need for a modernized or "smart" transmission system. A few commenters recommended specific goals such as 15-20% renewable generation capacity by 2020, 60-70% nuclear generation capacity by 2029, and a 1% annual increase in energy efficiency savings through 2020. Many commenters recommended that TVA take a leadership role (or reestablish its former leadership role) in the research and development of a wide range of supply- and demand-side options.

Environmental Impacts of Power System Operations

A majority of the commenters expressed concerns about the environmental impacts of the TVA power system. General concerns about pollution were the second most frequently mentioned issue, and over half of questionnaire respondents ranked the issues of air pollutants, greenhouse gas emissions/climate change, spent nuclear fuel, and coal combustion by-products with high importance.

The Kingston Fossil Plant ash spill in December 2008 was frequently mentioned. Many written comments encouraged TVA to decrease its emissions of greenhouse gases while others questioned the human influence on climate change. Several commenters also raised the issue of the impacts of buying coal from surface mines, particularly mountain-top removal mines, and recommended that TVA stop this practice.

Options to Be Evaluated

Scoping participants recommended a large number of traditional and non-traditional supply- and demand-side resource options. TVA has evaluated an extensive list of options, including the traditional industry standard supply and demand side options, options proposed by public commenters during public scoping, and options identified by TVA staff but not widely employed in the industry currently for various reasons. Each option was characterized by a suite of factors and initially screened with various feasibility criteria. The feasible resource options were then placed into groupings consisting of specific combinations of supply- and demand-side options.

2.2 Analysis and Evaluation Period

TVA used three techniques to collect public input during the analysis and evaluation period:

1. Stakeholder Review Group (SRG)
2. Quarterly Public Briefings
3. Phone Surveys

2.2.1 Stakeholders' Review Group

In addition to the public scoping efforts, TVA recognized that it would be difficult to get specific and continuous guidance from the public as the plan developed beyond the scoping period. To obtain more in-depth, ongoing discussion and input from different stakeholder viewpoints throughout the IRP development process, TVA established a Stakeholder Review Group (SRG). The 16-member review group is composed of representatives of state agencies, government, TVA distributors, industrial groups, academia, and non-governmental organizations. In addition to providing their individual views to TVA, SRG members represent their constituency and report to them on the IRP process.

The members of the Stakeholder Review Group and their affiliations are as follows:

Lance Brown, Executive Director
Partnership for Affordable Clean Energy
Montgomery, Alabama

Dana Christensen, Associate Director
Oak Ridge National Laboratory
Oak Ridge, Tennessee

Ryan Gooch, Director, Energy Policy
Tennessee Dept. of Economic and Community Development
Nashville, Tennessee

Louise Gorenflo
Sierra Club
Crossville, Tennessee

Richard Holland
Tennessee Paper Council
Nashville, Tennessee

George Kitchens, General Manager
Joe Wheeler Electric Membership Corporation
Trinity, Alabama

Henry List, Deputy Secretary
Kentucky Energy and Environment Cabinet
Frankfort, Kentucky

David McKinney, Environmental Services Division Chief
Tennessee Wildlife Resource Agency
Nashville, Tennessee

Jerry Paul, Distinguished Fellow on Energy Policy
Howard Baker Jr. Center for Public Policy
Knoxville, Tennessee

David Reister
Environmental Stakeholder
Knoxville, Tennessee

Jan Simek, Acting President
University of Tennessee
Knoxville, Tennessee

Jack Simmons, President and CEO
Tennessee Valley Public Power Association
Chattanooga, Tennessee

Stephen Smith, Executive Director
Southern Alliance for Clean Energy
Knoxville, Tennessee

Patrick Sullivan, Policy Advisor
Office of Governor Haley Barbour
Jackson, Mississippi

Lloyd Webb
Tennessee Valley Industrial Committee
Cleveland, Tennessee

Deborah Woolley, President
Tennessee Chamber of Commerce and Industry
Nashville, Tennessee

The SRG met approximately monthly with TVA beginning in July 2009, and held 10 meetings prior to the release of the draft IRP and associated environmental impact statement. These meetings were held at various locations throughout the Valley. Additional meetings are scheduled after the draft IRP and EIS public comment period closes.

The purpose of the SRG is to:

- Provide TVA with in-depth, ongoing input from different stakeholder viewpoints.
- Serve as a source of information, a coordination mechanism, and a professional review group.
- Build efficiency into the study process by providing real-time public input to IRP issues and processes.
- Validate the various steps in the IRP process.

Meeting types included working sessions and workshops. Working sessions were regular meetings, while workshops provided more in-depth information on specific topics to those members interested in attending. At each meeting, TVA facilitated discussions among SRG members on the issues they believed were important to a successful IRP. The individual views of SRG members were collected on the entire range of assumptions, analytical techniques, and proposed energy resource options and strategies. Given the diversity of the makeup of the SRG, there were at times a wide range of views on specific issues. Open discussions among SRG members and TVA staff, supported by data, brought closer understanding of particular issues.

To increase public access and transparency to the IRP process, all non-confidential meeting material (presentations, agenda, minutes) have been posted to the IRP project website at tva.gov/irp. During the course of the meetings, bridges of understanding and guidance were built that enhance the quality of this IRP.

2.2.2 Quarterly Public Briefings

In addition to the public scoping meetings described above, TVA held three quarterly public briefings on November 16, 2009, February 17, 2010, and May 13, 2010. Participants could attend in person or by webinar. The format of the public briefings included a brief presentation followed by a moderated Q&A session with the audience. Topics discussed at the public briefings included an introduction to the resource planning process, resource options, development of scenarios and strategies, and evaluation metrics. The public briefings attendance averaged 15-20 in-person participants and approximately 30-40 participants by web conference. Videos of the briefings and presentation materials have been posted on the IRP project website.

2.2.3 Phone Survey

In the initial phase of the IRP, TVA held various public listening sessions and public meetings throughout the Valley. During the sessions and meetings, TVA employees answered questions and solicited public response to identify the public's issues and concerns about TVA's resource planning. In addition, a scoping questionnaire was distributed to participants at these sessions and the results were used to develop a scoping report. Based on these results, TVA conducted a broader phone survey of 1,000 end-use customers across the Valley to:

- Determine primary power generation concerns among the residents of the TVA service area (cost, reliability, use of renewables, etc).
- Determine market potential for voluntary and financially incentivized energy efficiency programs.
- Determine market potential of renewable programs, including Green Power Switch and other existing or planned energy efficiency and demand response programs.
- Estimate potential market pricing for renewable power programs, including the additional amounts Valley residents are willing to pay each month for energy from renewable sources.

- Assess Valley residents' attitudes of and satisfaction with TVA, including analysis of each of the services that the organization provides to the Valley.

Initial results indicate that residents within the Valley hold a favorable attitude of TVA, consider system reliability as a critical component of utility services, and would like to see TVA focus on keeping prices affordable.

Full results of the survey will be incorporated into the final IRP report and actions plans.

2.2.4 Overview of Comments Received During the Analysis and Evaluation Period

As was expected, comments received during the analysis and evaluation period were noticeably more detailed than comments received during the initial scoping period. At this point in the IRP process, the public had access to considerably more information on the IRP planning process and was able to ask more specific questions on areas of particular interest with the benefit of better information.

Comments and questions covered a wide spectrum of specificity and subjects. These included specific questions on how the IRP could allow TVA to create infrastructure around future technology projects such as electric transportation and hydrogen fueling stations. Others expressed concerns with respect to TVA's existing fossil generation, particularly coal-fired generation, in light of the uncertainties surrounding future CO_2 price and siting requirements.

Some comments received focused solely on the process used for TVA's IRP planning. For instance, concerns were expressed about changing conditions and TVA's ability to adjust and react using the evaluation process were common among the public. Other concerns surrounding the planning process included the reliability and accuracy of market forecasts in developing the scenarios and questions pertaining to what extent the IRP captures aspects such as retirements fund needs, Kingston issues, and dry ash conversion.

Like the scoping period, these comments greatly assisted TVA in identifying the relevant concerns of the public with respect to resource planning.

2.2.5 Stakeholder Concerns

During the Analysis and Evaluation Period, TVA received ongoing feedback from various stakeholders (such as the SRG) about a variety of issues related to the IRP process, modeling assumptions, and preliminary results. These strategic points of debate include:

- **Aggressiveness of EEDR initiatives** – Concerns in this category include questions about the target level of EEDR being studied; the potential for larger amounts of EE that may potentially displace new nuclear capacity; uncertainty about cost, lost revenue impacts and program effectiveness; and questions about measurement and verification of benefits.
- **Renewable Additions to the Resource Portfolio** – This category includes a desire by some stakeholders to make more investments in options inside the Valley as opposed to imported wind power; or questions about system operational impacts caused by intermittent or off-peak resources like wind and solar.
- **Cost of New Capacity** – This category includes concerns about the ability of TVA to design, build and deliver major new capacity (like nuclear) on time and within budget; and questions about the reasonableness of construction cost estimates for new nuclear capacity.
- **Financing Requirements and Rate Implications** – In this category, stakeholders expressed significant concerns about TVA's ability to fund future resource additions due to the current limit on TVA's statutory debt, referred to as the debt ceiling. There were also concerns about potential impacts on short term rates, since TVA's financing options for generation expansion and other types of capital investments are limited to borrowings (limited by the current $30 billion debt ceiling), and increasing rates to cover the costs of construction, although some stakeholders believe that higher rates may promote more energy efficiency investments.
- **Coal Fleet Asset Strategy** – This category includes questions about the economic and environmental implications of idling certain coal-fired units; concerns about TVA's risk exposure for pending carbon legislation; and issues related to lead-time for positioning fossil assets for layup, retirement, and/or return to service.

TVA is considering these issues, along with the public input received to date, as it develops the final IRP report and encourages reviewers of this draft to submit comments about these or similar issues.

2.3 Draft IRP Public Comment Period

TVA will use three techniques to collect public input during the draft document stage:

1. Public Meetings
2. Webinars
3. Written Comments

2.3.1 Public Meetings

Beginning in October 2010, TVA will host four public meetings across the Tennessee Valley. Notice of these meetings will be announced in local and regional newspapers and other media. The meetings will be held in the following cities:

- October 5, 2010 - Bowling Green, Ky.
- October 7, 2010 - Olive Branch, Miss.
- October 13, 2010 - Knoxville, Tenn.
- October 14, 2010 - Huntsville, Ala.

At each of these meetings, TVA plans to present an overview of the draft IRP followed by a moderated Q&A session with a panel of TVA staff. Attendees will be able to address comments or questions to the panel. A transcript and video of each meeting will be recorded. Attendees also have the option of submitting written or verbal comments to a court reporter, should they not wish to address the panel publicly.

2.3.2 Webinars

In conjunction with the four public meetings, members of the public can participate in the public meetings by webinar. Attendees register in advance and are able to access the presentation and participate in the Q&A session from their home computer.

2.3.3 Written Comments

TVA has provided 45 days for receipt of written comments. Comments can be submitted on the IRP project website, emailed, mailed, or faxed to TVA, or provided at one of the public meetings.

2.3.4 Overview of Comments Received During Draft IRP Public Comment Period

TVA will capture all substantive, relevant comments on the IRP and address them in the final IRP and/or associated EIS.

Chapter 3 – Need for Power Analysis

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3 Need for Power Analysis

In analyzing the need for power, TVA begins with its long-term forecasts of the growth in demand for electricity (for the purposes of this IRP, through 2029), both in terms of electricity sales to the end user, and the peak demands those end users place on the TVA system. It then identifies the current supply- and demand-side resources available to meet this demand. The final step is comparing the demand with supply and using the resulting gap to arrive at a need for generating assets or demand-side options.

3.1 Power Demand

3.1.1 Methodology

As discussed above, any determination of a need for power begins with a long-term forecast of energy sales and peak demand. These long-term forecasts are developed from individual, detailed forecasts of residential, commercial and industrial sales and serve as the basis for all planning, including generation and financial planning activities.

TVA's load forecasting is a complex process that starts with the best available data and is carried out using both econometric (statistical economic) and engineering, or end-use models. TVA's econometric models link electricity sales to several key economic factors (hence the term, econometric) in the market, such as the price of electricity, the price of competing energy source options like natural gas, as well as growth in overall economic activity (generally measured by changes in the Gross State Product). Specific values for key variables are used to develop forecasts of sales growth in the residential and commercial sectors, as well as in each industrial sector. Underlying trends within each sector, such as the use of various types of equipment or processes, play a major role in forecasting sales. To capture these trends and changes in the stock and efficiency of equipment and appliances, TVA uses a variety of end-use forecasting models. For example, in the residential sector, sales are forecast for space heating, air conditioning, water heating and several other uses after accounting for other important factors like changes in efficiency over time, appliance saturation and replacement rates, and growth in the average size of the American home. In the commercial sector, a number of end-use categories, including lighting, cooling, refrigeration and space heating, are examined with a similar attention to changes in other important variables like efficiency and saturation.

Forecasting is inherently uncertain, so TVA supplements its modeling with industry analyses and studies of specific major issues that have the potential to impact those forecasts. Further, TVA also produces alternative regional forecasts based on different outcomes for key drivers like economic growth, population growth, or economic behaviors of some of TVA's largest wholesale customers. Two of these alternative forecasts, referred to internally as the high and low load forecasts, define a range of possible future outcomes with a high level of confidence that the true outcome will fall within this range. This ensures that TVA's resource planning takes account of the variability that is the hallmark of year-on-year peak demand and energy sales.

As discussed above, several key inputs are used as drivers of the long-term forecasts of residential, commercial and industrial demand. The most important of these are economic activity, the price of electricity, customer retention, and the price of other sources of energy including natural gas.

Economic Activity

Periodically, but at least annually, TVA produces a forecast of regional economic activity for budgeting, long-range planning and economic development purposes. These forecasts are based on national forecasts developed by www.economy.com, an internationally recognized economic forecasting service.

The economy of the TVA service territory has historically been more dependent on manufacturing than the U.S. as a whole, with industries such as pulp and paper, aluminum, steel, and chemicals drawn to the region because of the wide availability of natural resources, reliable, competitively priced electricity, and access to a skilled workforce. In recent years, regional growth has outpaced national growth because manufacturing activities have grown at a faster pace than non-manufacturing activities. However, this can also mean that in periods of recession, regional growth will contract faster, and more sharply, given this relatively higher degree of dependence on manufacturing. The flip side of this, as has been evidenced by the recovery from the most recent recession, is that the regional economy also tends to recover more quickly and robustly.

Future growth is expected to be lower than historical averages as a result of the impacts of the recent recession and subsequent recovery as well as the trend of declining U.S. manufacturing. As markets for manufacturing industries have become global in reach, production capacity has moved from the TVA region overseas for many of the same reasons that the industries first moved to the TVA region. The contraction of these industries, and the load growth associated with them, has been offset to some degree by the growth of the automobile industry in the Southeast in the last 20 years. Although the TVA region is expected to retain its comparative advantage in the automotive industry, as exemplified by the new Volkswagen auto plant under construction in Chattanooga, Tennessee, reduced long-term prospects for the U.S. automotive industry will also have an impact on the regional industry.

Other impacts from the recent recession—increased financial market regulation, tighter credit conditions, as well as large federal budget deficits—may also work toward restraining growth. These changes could persist in the long term with the result being that overall economic growth for the TVA region and the nation being somewhat below TVA's previous expectations.

Population growth in the Valley, however, continues to be strong. Most migration into the region is still primarily driven by economic opportunities—migration out of contracting sectors and into the Valley's expanding sectors. Part of this growth is to serve the existing population (retail and other services), but more importantly, a growing part is related to "export" services that are "sold" to areas outside the region. Notable examples are corporate headquarters such as Nissan and Hospital Corporation of America, which is the largest private operator of hospitals in the world, in Nashville; and FedEx, Autozone, International Paper, and Service Master in Memphis. In addition, the Tennessee Valley has become an attractive region for the growing ranks of America's retirees (increasingly fueled as Baby Boomers exit the workforce) looking for a moderate climate and a more affordable region than traditional retirement locations. The increase in retiree population has a multiplier effect in the service sector, increasing the need for employees to meet growing demand.

Price of Electricity

Forecasts of the retail price of electricity are based on long-term estimates of TVA's total costs to operate and maintain the power system adjusted to include an estimate of the historical markups charged by distributors. These costs, known in the industry as revenue requirements, are based on estimates of the key costs of generating and delivering electricity, including fuel, variable operations and maintenance costs, capital investment and interest. High and low electricity price forecasts are also derived using high and low values for these same factors after accounting for any relationships that may exist between variables.

Customer Retention

Over the last 20 years, the electric utility industry has undergone a fundamental change in most parts of the country. In many states, an environment of regulated monopoly has been replaced with varying degrees of competition. Wholesale open access (the rights of wholesale customers to buy power from generating utilities other than the utility that owns the transmission and distribution lines that serve them) is largely mandated by the Federal Energy Regulatory Commission (FERC).

While TVA has contracts with its 155 distributors of TVA power, it is not immune to competitive pressures. Those contracts with distributors allow distributors to give TVA notice of contract cancellation, after which they may procure power from other sources. Many of TVA's large directly served customers have the option to shift production from plants served by TVA to plants in other utility service territories, provided TVA's rates are not competitive with those of the utilities serving those territories. In the IRP Baseline forecast, TVA's price of electricity is expected to remain competitive with the rates of other utilities. As a result, the net impact of competition in the medium forecast is that TVA will retain the majority of its current customer base.

Price of Substitute Fuels

Electricity is a source of energy. The utility derived from consuming electricity can also be obtained using other sources of energy, where applications allow. If the price of electricity is not competitive with the price of other fuels, where those fuels can be utilized to provide the same energy services as electricity (i.e. water and space heating), customers may substitute away from electricity in the long term, and into cheaper sources of energy, where possible. The potential for this type of substitution to occur will depend on the relative prices of other fuels, as well as the physical capability to do so. For example, while consumers can take action to change out electric water heaters and replace electric heat pumps with natural gas furnaces, the ability to utilize another form of energy to power consumer electronics, lighting and many appliances is far more limited by current technology.

Changes in the price of TVA's electricity compared to the price of natural gas and other fuels will influence consumers' choices of appliances—either electric, gas or other fuels. While other substitutions are possible, natural gas prices serve as the benchmark for determining substitution impacts in the load forecasts.

3.1.2 Forecast Accuracy

Forecast accuracy is generally measured in part by error in the forecasts, whether day ahead, year ahead, or multiple years ahead. Figures 3-1 and 3-2 show annual forecasts from 2000 through 2009 for net system requirements and peak load requirements as compared to actual energy use and peak loads, respectively. The mean annual percent error (MAPE)[1] of TVA's forecast of net system energy requirements for the 2000-2009 period was 1.9% and 2.8% for peak load requirements. These include large errors in 2009 as the ramifications of the 2008 financial crisis and resulting economic slowdown affected the remainder of the economy. In the TVA service area, the most significant reductions were in the industrial sector, and it has already begun to show signs of recovery. The 2000-2008 MAPE was 1.1% for net system requirements and 2.2% for peak load, which is more representative of the accuracy of TVA year-in and year-out load forecasts. Though TVA has not conducted a formal benchmark on this metric, from conversations with other utilities at conferences and working groups, our MAPE's appear to be in line with others', which is around 1-2%.

As mentioned above under Economic Activity, while the economy in the Valley may be slightly stimulated by the creation of "export" services sold to areas outside the TVA region, future growth is expected to be lower than historical averages as a result of a number of factors, including the impacts of the recent recession and subsequent recovery, the trend of declining U.S. manufacturing, and the projected loss of some TVA customer load.

[1] MAPE is the average absolute value of the error each year; it does not allow over-predictions and under-predictions to cancel each other out.

Figure 3-1 and Figure 3-2 indicate the magnitude of the downturn of TVA net system requirements and summer peak loads due in part to the recession in the region. Figure 3-1 is a comparison of actual and forecasted net system requirements expressed in total annual energy (GWh). Figure 3-2 is a comparison of actual and forecasted summer peak demand in MW's.

The trends shown in Figures 3-1 and 3-2 are the result of a decline in energy usage by TVA customers, due to a combination of factors including changes in the regional economy, improved efficiency and rising prices. Note also that the "Norm. Actual" line represents the normalized value of the annual energy, meaning abnormal weather impacts have been removed.

Figure 3-1 – Comparison of Actual and Forecasted Net System Requirements

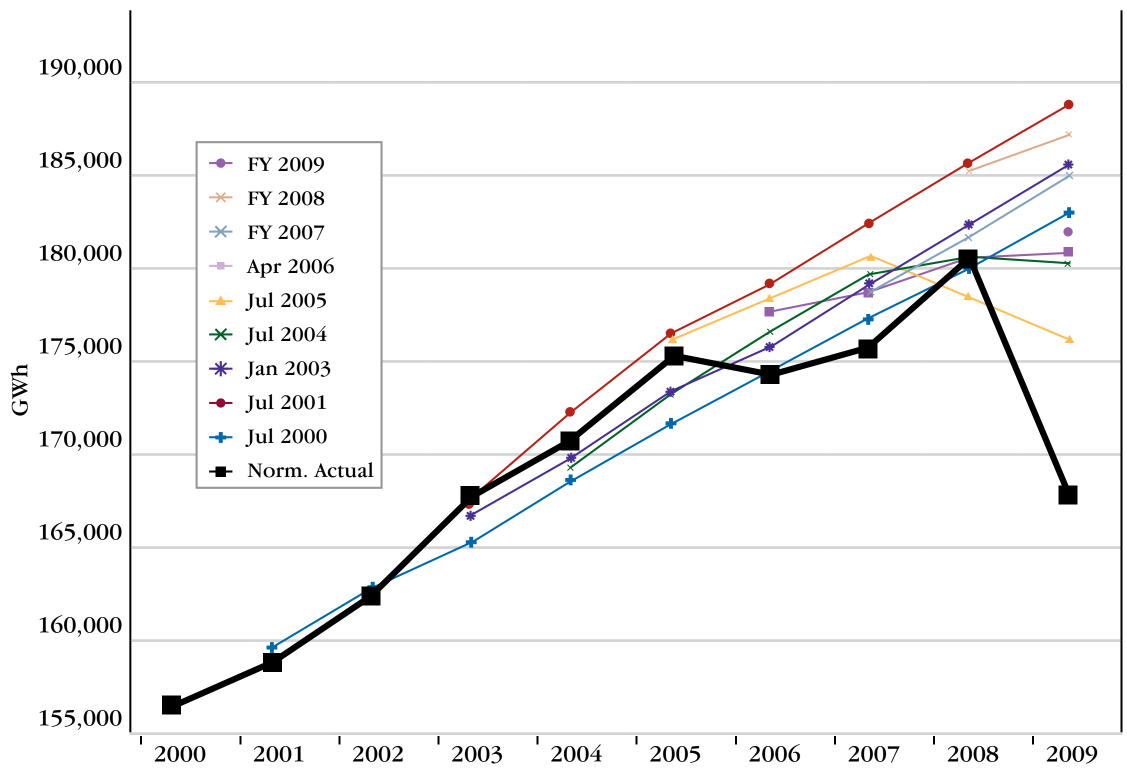
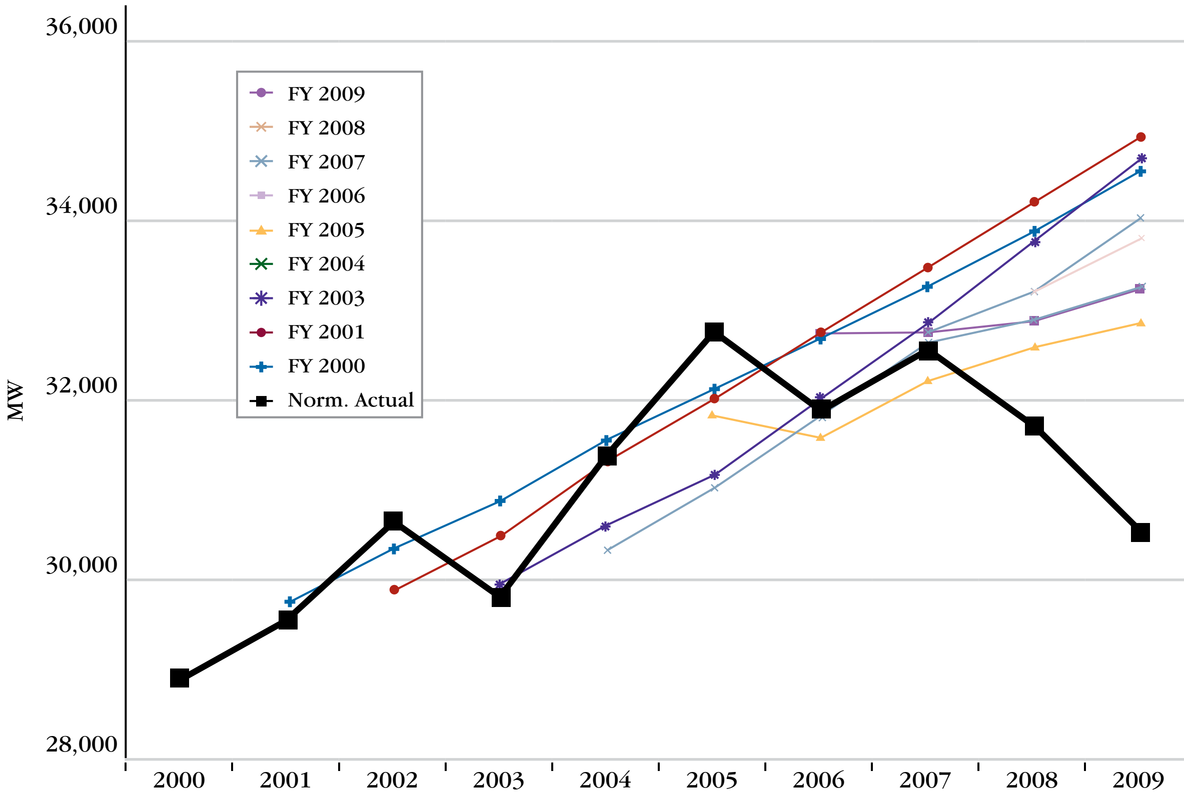


Figure 3-2 – Comparison of Actual and Forecasted Summer Peak Demand



3.1.3 Forecasts of Peak Load and Net System Requirements

To deal with the uncertainty inherent in forecasting, TVA has developed a range of forecasts, with each forecast corresponding to a different load scenario. Scenarios are described in Chapter 5. Forecasts of net system peak load and energy requirements for the IRP Baseline and the highest and lowest scenarios are shown in Figures 3-3 and 3-4, respectively. Peak load grows at an average annual rate of 1.3% in the IRP Baseline, varying from 0% in the lowest scenario to 2% in the highest scenario. Net system energy requirements grow at an average annual rate of 1% in the IRP Baseline, varying from 0% in the lowest scenario to 1.9% in the highest scenario.

The use of ranges ensures that TVA considers a wide spectrum of electricity demand in its service territory and reduces the likelihood that its plans are too dependent on the achievement of single point estimates of demand growth that make up the midpoints of the forecasts. These ranges are used to inform planning decisions beyond pure least-cost considerations given a specific demand in each year.

The IRP Baseline is impacted by the recent recession that slowed load growth in the short-term and adds uncertainty to the forecast of power needs; however, economic recovery is expected and future power needs are expected to grow but at a rate lower than historical averages.

Figure 3-3 – Peak Load Forecast

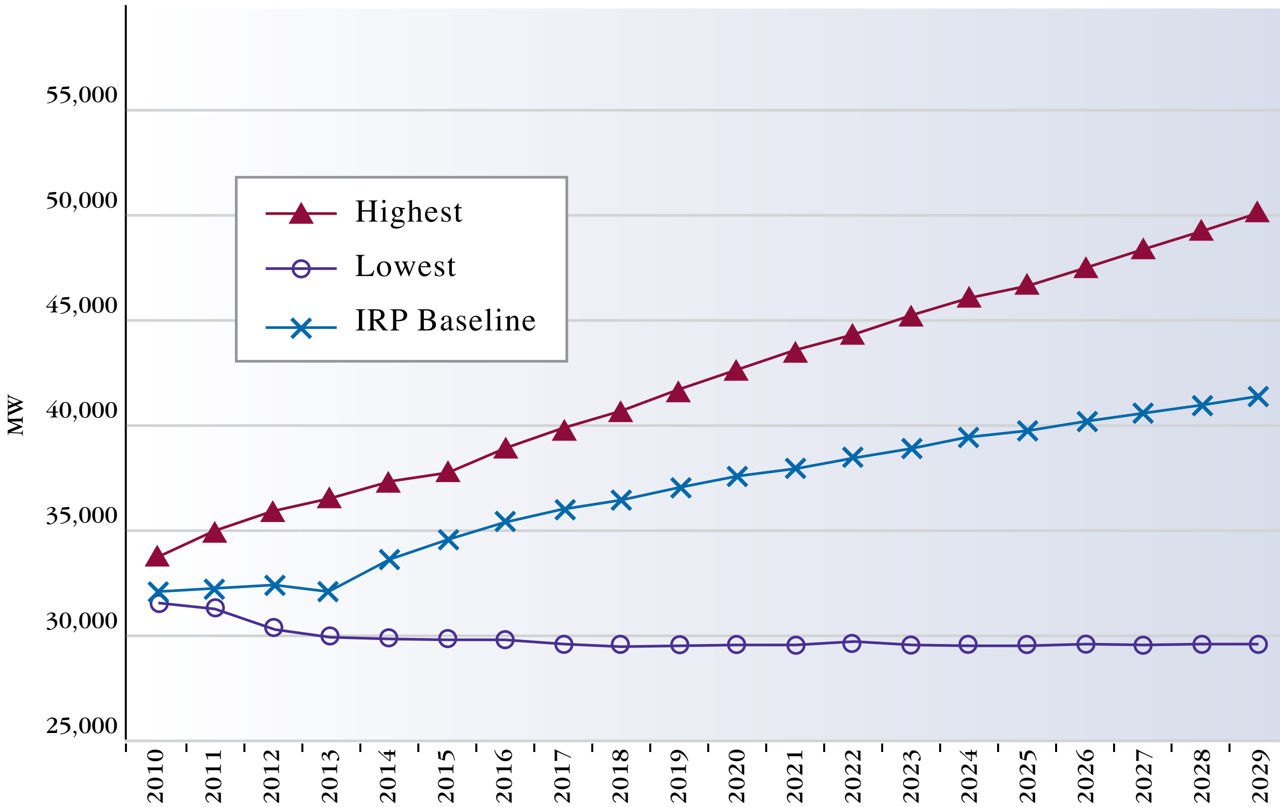
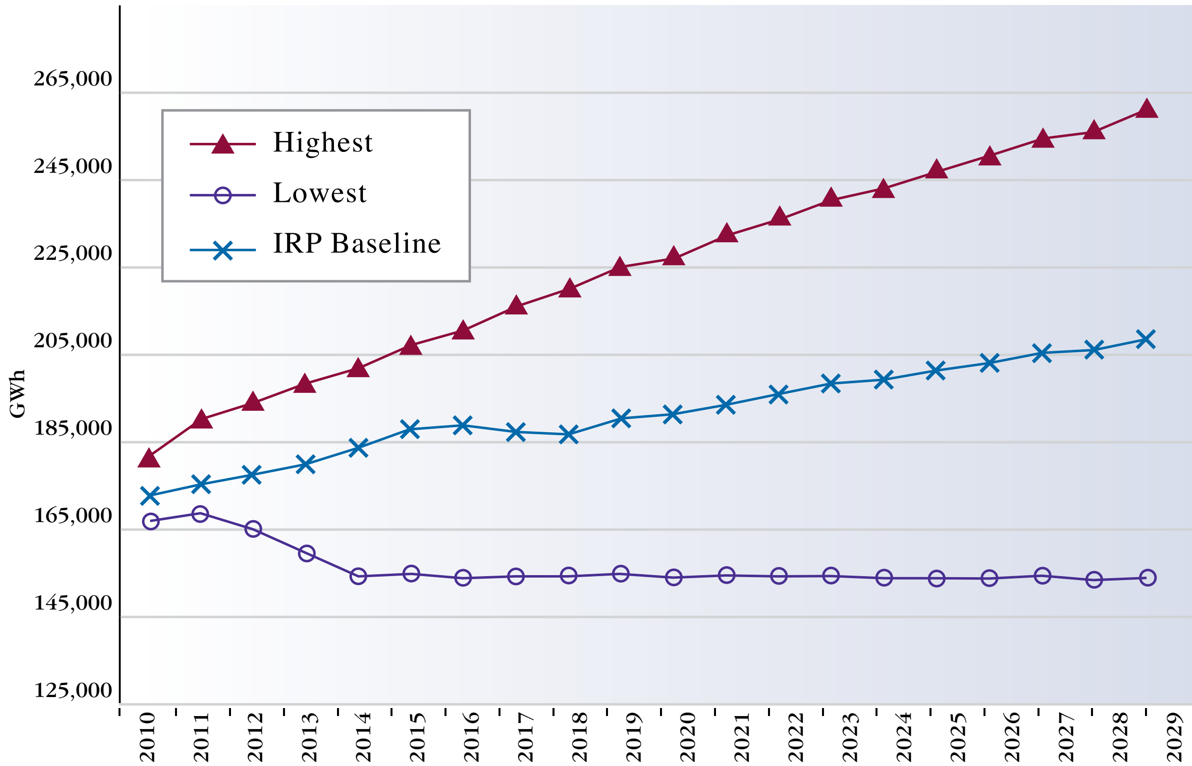


Figure 3-4 – Energy Forecast



3.2 Power Supply

TVA's generation supply consists of a combination of existing TVA-owned resources, budgeted and approved projects (such as new plant additions and uprates to existing assets), and power purchase agreements (PPAs) that give TVA a contractual right to the capacity and output of generating assets not owned by TVA. This supply includes a diverse portfolio of coal, nuclear, hydroelectric, natural gas and oil, market purchases, and renewable resources designed to provide reliable, low cost power while minimizing the risk of disproportionate reliance on any one type of resource. Each type of generation can be categorized based on its degree of utilization for supplying base load, intermediate, peaking or storage generation. Generation can also be categorized by capacity, energy type and how it is measured.

Figure 3-5 – Illustration of Peaking, Intermediate, and Base load Resources

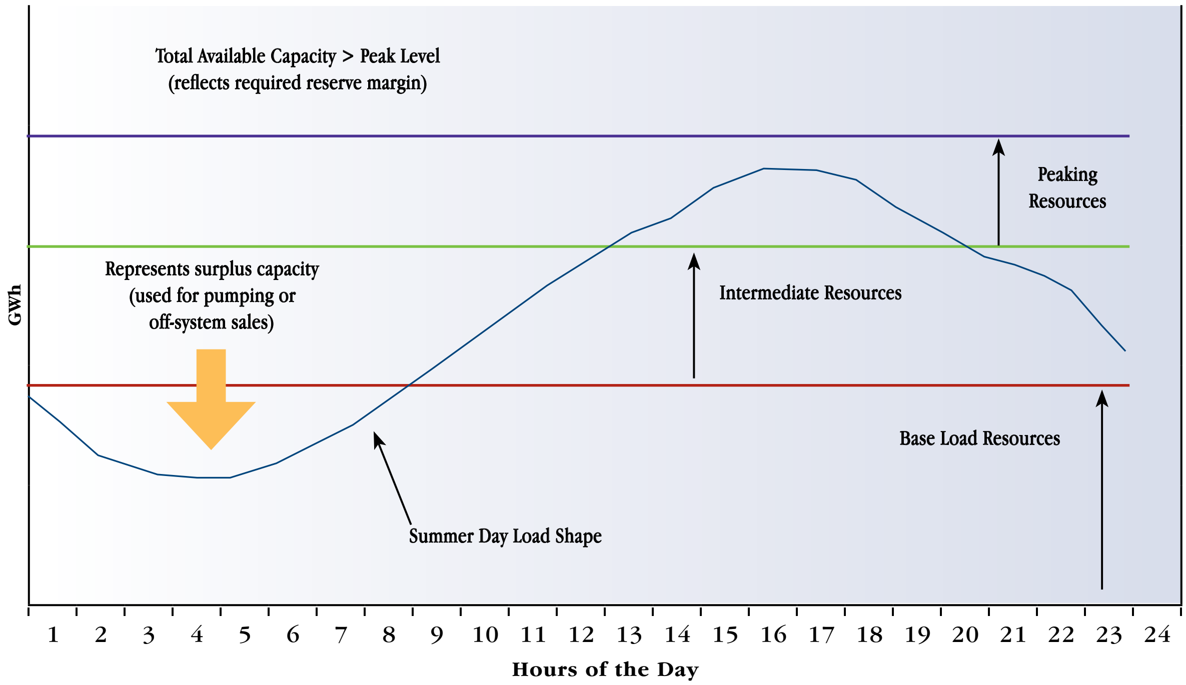


Figure 3-5 illustrates the uses of peaking, intermediate and base load generation. Although these categories are useful, the distinction between them is not always clear-cut. For example, a peaking unit may be called on to run continuously for some time period like a base load unit, although it is less economical to do so. Similarly, many base load units are capable of operating at different power levels, giving them some of the characteristics of an intermediate or peaking unit. This IRP considers strategies that take advantage of this range of operations.

3.2.1 Base Load Resources

Base load generators are primarily used to meet continuous energy needs because they have lower operating costs and are expected to be available and operate continuously throughout the day. These base load resources typically have high capital costs, but these higher capital costs are usually offset by favorable fuel costs, especially when fixed costs are expressed on a unit basis. This type of energy is generated from technologies that can provide continuous, reliable power over long periods of uniform demand, such as base load coal plants and nuclear reactors. Some energy providers may consider combined-cycle plants for incremental base load generation needs; however, given the tendency for natural gas prices to be higher than coal and nuclear fuel prices, combined cycles may be a more expensive option for larger continuous generation needs, at least given recent fuel prices. As the fundamentals of fuel supply and demand change in the future, and as access to shale gas continues to grow, this relationship may change in the future.

3.2.2 Intermediate Resources

Intermediate resources are primarily used to fill the gap in generation between base load and peaking needs. These units are required to produce more or less output as the energy demand increases and decreases over time (usually during the course of a day). Intermediate units are more costly to operate than base load units but cheaper than peaking units. This type of generation typically comes from natural gas-fired combined cycle plants and smaller coal plants. Corresponding back-up balancing supply needed for intermittent renewable generation (such as wind or solar) also comes from intermediate resources. It is possible to use the energy generated from a solar or wind project as an intermediate resource with the use of energy storage technologies.

3.2.3 Peaking Resources

Peaking units are only expected to operate infrequently, mainly during shorter duration, high demand periods. They are essential for maintaining system reliability requirements, as they can ramp up quickly to meet sudden changes in either demand or supply. Typical peaking resources include natural gas-fired combustion turbines (CTs), conventional hydroelectric generation and pumped-storage, and renewable resources.

3.2.4 Storage Resources

Storage units usually serve the same power supply function as peaking units, but use low cost off-peak electricity to store energy for generation later at peak times. An example of a storage unit is a hydro pumped-storage plant that pumps water to a reservoir during periods of low demand and releases it to generate electricity during periods of need. Consequently, a storage unit is both a power supply source and an electricity user.

3.2.5 Capacity and Energy

Power system peaks are measured in terms of capacity (e.g. MW), which is the instantaneous maximum amount of energy that can be supplied by a generator. For long term planning purposes, capacity can be specified in many forms, such as nameplate (the maximum design generation), dependable (the maximum that can typically be expected in normal operation), seasonal (the maximum that can be expected during different seasons of the year) and firm (dependable capacity less all known adjustments).

Overall power system usage is measured in terms of energy (e.g. MWh or GWh). Energy is the total amount of power that an asset delivers in a specified time frame. For example, one MW of power delivered for one hour equals one MWh of energy. Capacity factor is a measure of the actual energy delivered by a generator compared to the maximum amount it could have produced. Assets that are run constantly such as nuclear or fossil plants provide a significant amount of energy (higher capacity factor). Assets that are used infrequently such as combustion turbines provide relatively little energy (low capacity factor), although the energy they do produce is usually valuable since it often is delivered at peak times.

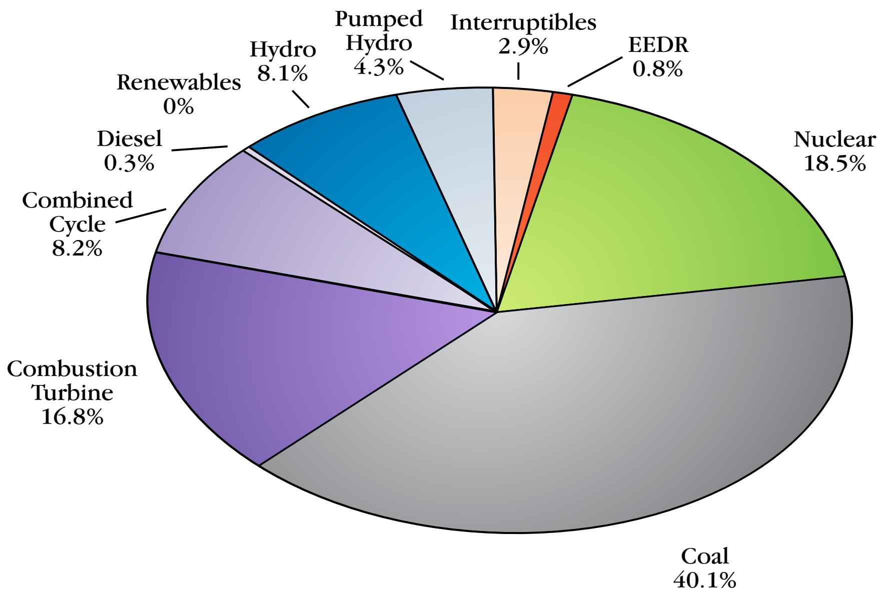
Energy efficiency measures can also be measured in terms of capacity and energy. Even though energy efficiency does not input power into the system, the effect is similar as it represents power that is not required. Demand reduction is also measured in capacity and energy, but unlike energy efficiency, it is not a reduction in total energy used.

3.2.6 TVA's Generation Mix

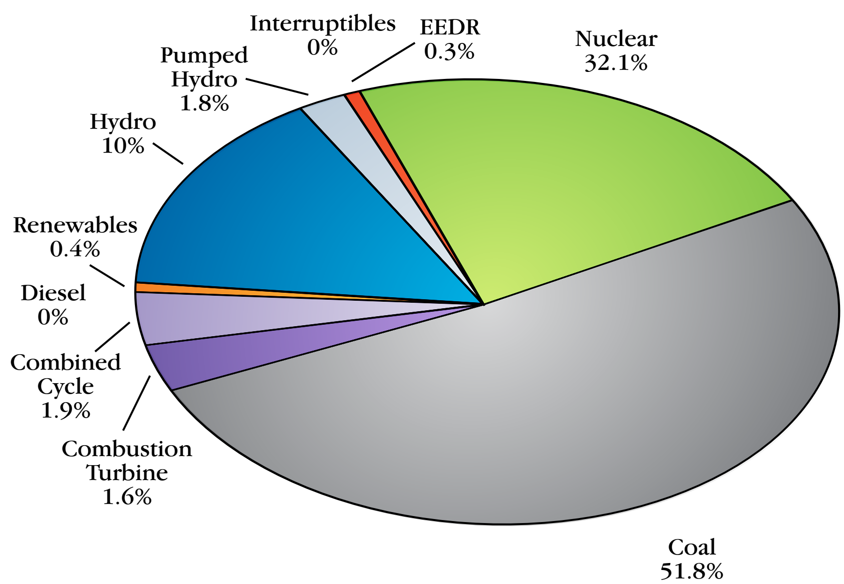
TVA's power generation system employs a wide range of technologies to produce electricity and meet the needs of the Tennessee Valley's more than nine million residents, businesses and industries. See Figure 3-6 for a breakdown of capacity and generation by technology for TVA's baseline portfolio. Note that for purposes of this IRP, the baseline portfolio is the long-term financial plan that was current as of spring 2010.

Figure 3-6 – Firm Capacity and Generation Mix

2010 Baseline Portfolio – Firm Capacity



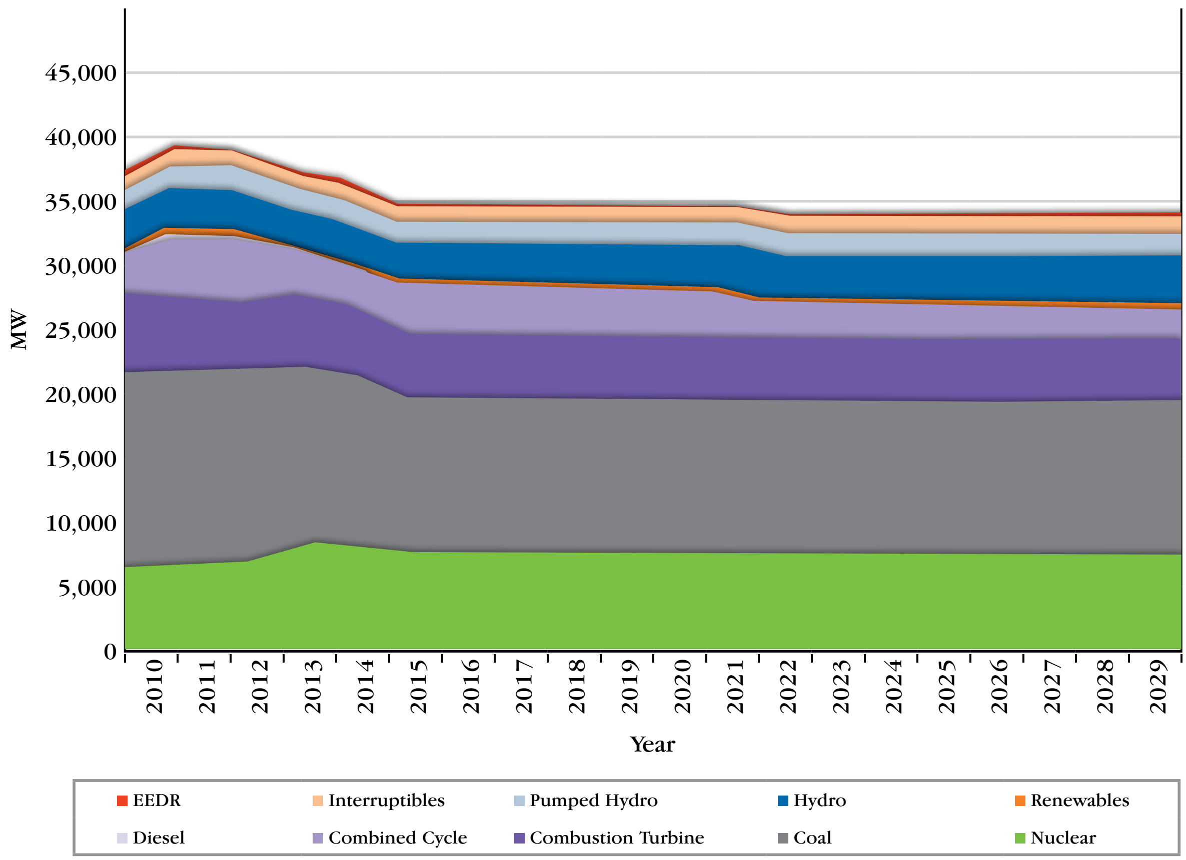
2010 Baseline Portfolio – Generation



In 2010, approximately 55% of TVA's electricity will be produced from coal and natural gas-fired plants (51.8% coal; 3.5% gas). Nuclear plants will produce about 32%, hydroelectric plants will produce approximately 12%, and most of the remaining generation will come from renewable sources. TVA's EEDR programs are also in place for avoided generation.

Figure 3-7 illustrates the changing composition of existing generating resources that are currently anticipated or "planned" (assumed in planning) to be operated through 2029. Figure 3-7 includes only those resources that currently exist or are under contract (such as PPAs and EEDR programs) and changes to existing resources that are planned and approved. The total capacity of existing resources decreases through 2029, primarily because of the potential lay-up of approximately 2000 MW of coal-fired capacity. Total capacity also decreases as PPAs expire. The renewable energy component of the existing portfolio is primarily composed of wind PPAs, which are discussed in Chapter 4. The current EEDR programs are 0.8% of the capacity and are explained in further detail in Chapter 4. As discussed in Section 6, all IRP strategies include additional renewable resources and EEDR programs beyond those depicted in Figure 3-7.

Figure 3-7 – Baseline Capacity Portfolio



3.3 Assessment of Need for Power

The TVA system is dual-peaking, with high levels of demand occurring in both the summer and winter months. The annual peak demand in 2008 and 2009 occurred in January with the 2009 demand reaching over 32,500 MW. Winter peaks are expected to continue for the next couple of years; thereafter, the forecasted peak load or the highest demand placed on the TVA system is projected to occur in the summer months.

To ensure that enough capacity is available to meet peak demand, including contingency for unforeseen events, additional generating capacity beyond that which is needed to meet peak demand is generally maintained. This additional generating capacity (known as "reserve capacity" or "operating reserves") must be large enough to cover the loss of the largest single operating unit (contingency reserves), be able to respond to moment-by-moment changes in system load (regulating reserves) and replace contingency resources should they fail (replacement reserves). Total reserves must also be sufficient to cover uncertainties such as unplanned unit outages; load forecasting error, including the difference between actual weather and forecast; normal weather; and undelivered purchased capacity.

TVA identifies a planning reserve margin based on minimizing overall cost of reliability to the customer. This reserve margin is based on a stochastic analysis that considers the uncertainty of weather, economic growth, unit availability and transmission capability to compute expected reliability costs. From this analysis a target reserve margin is selected such that the cost of additional reserves plus the cost of reliability events to the customer is minimized. This target (optimal) reserve margin is adjusted based on TVA's risk tolerance to produce the reserve margin used for planning studies. Based on this methodology, TVA's current planning reserve margin is 15% and is applied during both the summer and winter seasons.

That capacity gap is defined as the difference between the existing firm capacity from the IRP baseline case (shown in Figure 3-7) and the load forecasts (shown in Figure 3-3) adjusted for any interruptible customer loads plus reserve requirements. In other words, the capacity gap is the difference between total supply and total demand. Net system requirement is the required energy needed to serve the load over the entire year. It includes the energy consumed by the end users plus distribution and transmission losses. The need for power can be expressed in two ways: (1.) capacity gap in MW, which is the instantaneous generation gap during the peak hour of the year; and (2.) the energy gap in GWhs, which is the amount of energy provided by the new resources added in the baseline case that is needed to meet net system requirements after considering the contributions from existing resources.

Figure 3-8 shows the resulting capacity gaps based on the IRP Baseline peak load forecast, as well as the range corresponding to the highest and lowest scenario. Figure 3-8 shows the same comparison for the energy gaps. Figures 3-8 and 3-9 reflect the assumptions included in the IRP Baseline case (see Section 5.3 for details about these assumptions). These figures also show that, under most scenarios and in most years, TVA requires additional capacity and generation, or EEDR, to meet or offset forecasted capacity and energy needs. The IRP Baseline need for additional generating capacity, or EEDR programs, is 9,600 MW and 29,000 GWhs of additional generation in 2019, growing to 15,500 MW and 45,000 GWhs in 2029.

Section 6 addresses the alternative strategies by which TVA could acquire additional capacity and generation, including EEDR programs, to meet the need for power shown in Figures 3-8 and 3-9.

Figure 3-8 – Capacity Gap

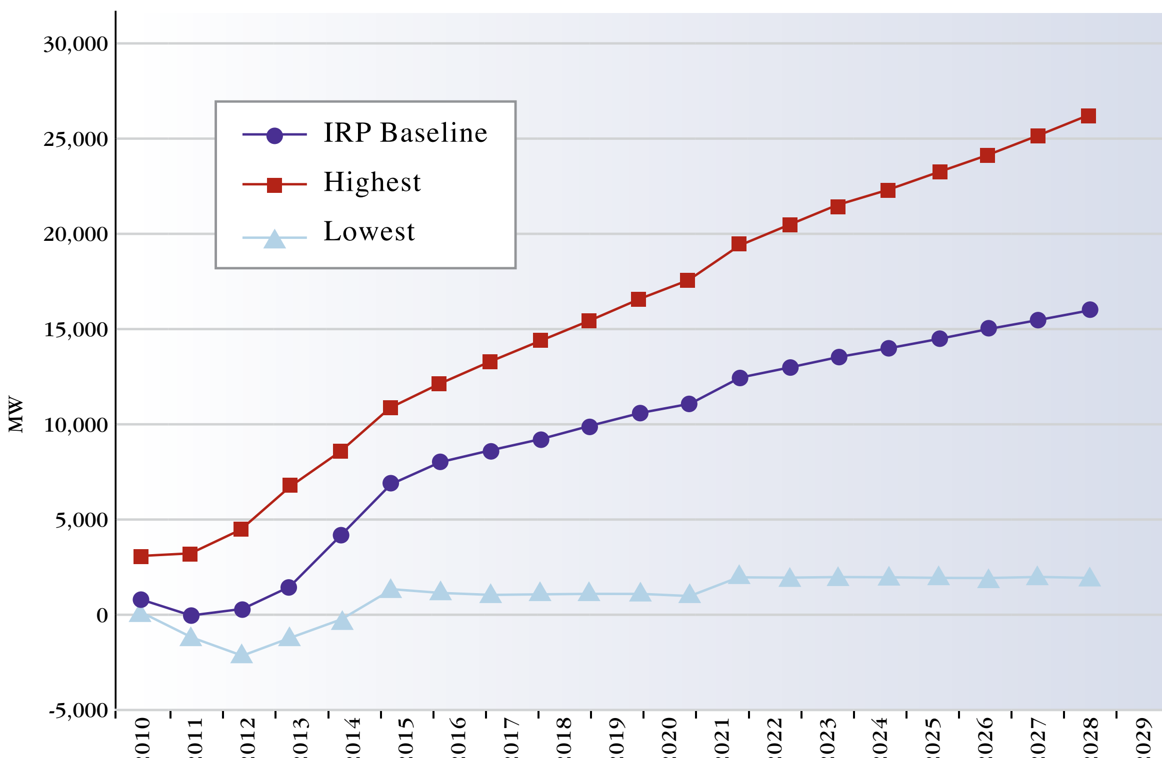
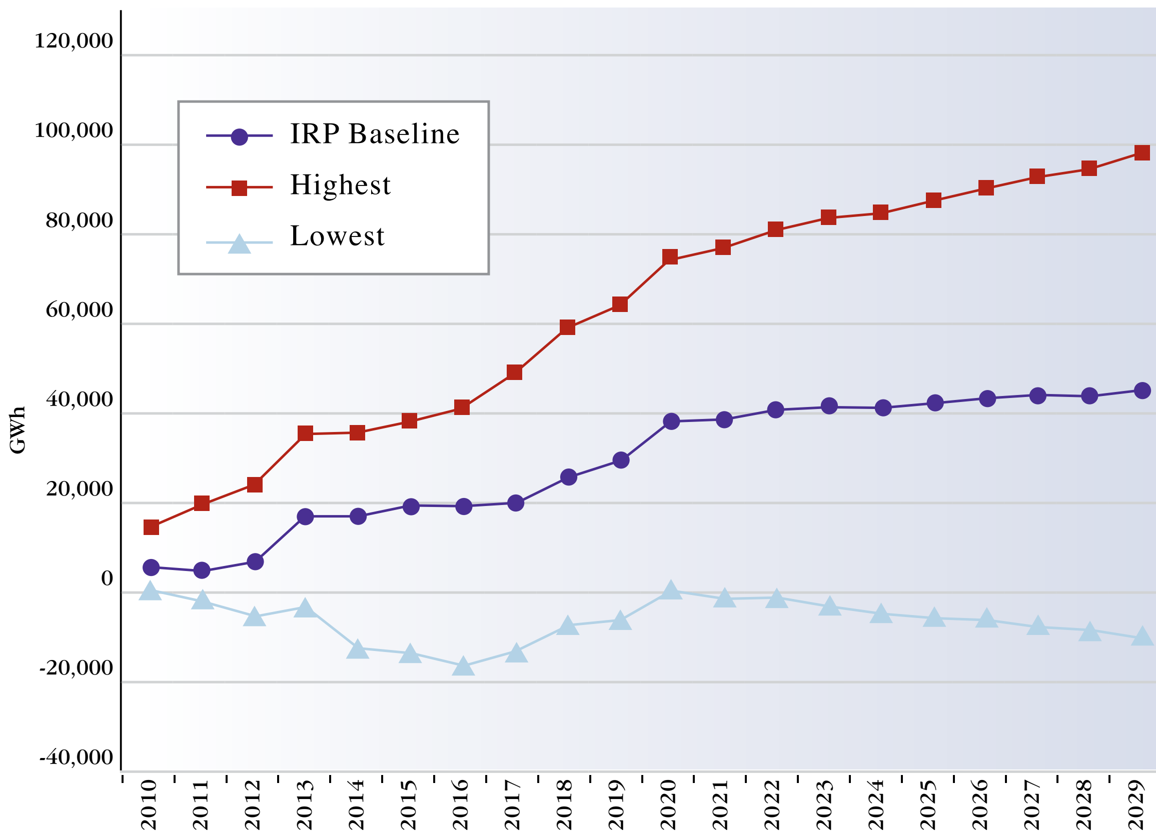


Figure 3-9 – Generation Gap



Chapter 4 – Energy Resource Options

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4 Energy Resource Options

4.1 Introduction

At the heart of its ability to provide low cost, reliable, clean electric power to the consumer are TVA's power generation and transmission systems. For TVA to continue providing low cost, reliable and clean electric power, it will need additional generating capacity as well as an increase in demand-side resources as discussed in Chapter 3, Need for Power.

In EV2020, TVA evaluated hundreds of different resource options and summarized its evaluations in the final combined IRP and EIS. To update those evaluations in this IRP, TVA has reviewed resource options that are currently or are expected to be commercially available by 2029. The purpose of this chapter is to describe these energy resource options, which of these options were focused on, and why.

The following criteria were applied to determine what options should be considered as viable in the IRP:

- The resource options must utilize a developed and proven technology, or one that has reasonable prospects of becoming commercially available before 2029.
- The resource options must be available to TVA, either within the TVA region or importable through market purchases.

- The resource options must be reasonably economical and contribute to the reduction of emissions of air pollutants, including greenhouse gases from the TVA power supply portfolio, in alignment with overall TVA objectives.
- The resource options should not be excessively risky or speculative.

TVA's future portfolio of generating assets must consist of a broad cross section of different technologies to support varying power demand. These technologies can be characterized by how often they are utilized for producing power (sometimes referred to as where they fit in the "duty cycle") and consist of peaking assets which respond quickly when power demand is very high for short periods of time; intermediate assets that respond reasonably quickly and fill the next level of power demand for longer periods; and finally, base load assets that meet a fairly constant level of power demand by operating for extended periods of time. In addition to these assets, storage units, which are used to store energy during off-peak periods for use during peak periods, will also be employed. Finally, TVA's portfolio is expected to include power purchases through both short- and long-term contracts, as well as demand-side options like energy efficiency and demand response programs (EEDR), where cost effective and reliable.

4.2 Options Identified but Not Further Evaluated

During the scoping process, TVA identified a broad range of resource options. The criteria listed in Section 4.1 were applied to these options to narrow them down to a more manageable portfolio based on the aforementioned criteria.

In general, there were four primary reasons these resource options were not considered for further analysis as separate options in the IRP:

1. The technology was still in very early stages in terms of maturity, either in the research phase or under development but not widely available during the IRP planning period.
2. The resource option was either previously considered by TVA and found to be uneconomic or not technically feasible.
3. The resource option is considered part of what private developers or individuals could elect to do as part of their participation in EEDR programs or their development of renewable resource purchase options for TVA consideration, but is not a resource option TVA would implement on its own.
4. The resource option is already part of TVA's resource plan.

4.3 Options Included in IRP Evaluation

This section identifies and describes the set of resource options that TVA considered in this IRP evaluation. Existing assets in TVA's current generation portfolio are described including owned facilities and power purchases. Options for new generation include owned assets and power purchases, and repowering of current assets is also considered. The main areas are fossil-fuel generation, nuclear generation, renewable generation, energy storage, and energy efficiency and demand response (EEDR).

Power purchases refer to the procurement of energy and/or capacity from other suppliers for use on the TVA system in lieu of TVA constructing and operating its own resources. TVA is currently party to numerous short- and long-term power purchase agreements and has included PPA options in its IRP evaluation. For all PPAs, TVA assumes the supplier will either interconnect with TVA transmission or obtain a transmission path to TVA, if outside the TVA region.

Repowering electrical generating plants is the process by which utilities update, change the fuel source or change the technology of existing plants to realize gains in efficiency or output not possible at the time the plant was constructed. TVA has included approved repowering projects in its forecast for existing resources and included other as-yet-unapproved repowering options in its IRP evaluation.

4.3.1 Fossil-Fueled Generation

4.3.1.1 Coal

Coal – Existing Generation

TVA currently operates 59 coal-fired generating units at 11 generating plants with a total capacity of 14,500 MW (net dependable). While some strategies assume the continued operation of all of these assets, others assume placing varying amounts of coal-fired generating capacity into long-term layup status for the foreseeable future. The goal of a long-term layup is the preservation of the asset so that it could be re-integrated into TVA's generating portfolio in the future if power system conditions were to warrant it.

In addition to its own coal-fired assets, TVA also has access to the output from a coal-fired power plant (of approximately 430 MW) through a long-term purchased power agreement.

Coal – New Generation

TVA has included supercritical pulverized coal (SCPC) plants with carbon capture and storage (CCS) technology, as well as integrated gasification combined cycle (IGCC) plants with CCS technology as resource options in its IRP evaluation. Pulverized coal, SCPC and IGCC options without CCS technology were not considered in the IRP evaluation due to their higher CO_2 emissions.

In a pulverized coal (PC) plant, finely ground (pulverized) coal is injected into the boiler with sufficient air to ensure combustion. In the boiler, heat is absorbed from the resulting hot gas to boil water and make steam, which then turns a steam turbine to generate electricity. Nitrous oxides (NO_x), sulfur dioxide (SO_2), and particulate matter are removed from the gas after it leaves the boiler and before it is released into the atmosphere. A supercritical PC (SCPC) plant is an advanced version of a PC plant. While it is technically similar to the PC plant, the exception is that the SCPC's supercritical boiler operates at supercritical steam pressures of greater than 3,200 pounds per square inch. The higher-pressure steam cycle provides greater efficiency, meaning more electricity per ton of coal burned in the process. Specifically, supercritical units have a thermal efficiency that is about two percentage points better than conventional sub-critical units as well as 5% lower emissions of SO_2, NO_x, mercury, and carbon dioxide (CO_2). CO_2 emissions are a function of the efficiency of the plant in converting heat from the coal burned into electricity, with the lowest CO_2 emissions from the plants with highest efficiency.

Two configurations of new SCPC plants are considered in the IRP evaluation:

1. Single-unit 800-MW SCPC plant with CCS
2. Two-unit 1600-MW SCPC plant with CCS

IGCC plants differ significantly from PC plants. They generate electricity in the same manner as natural gas-fired combined cycle plants (see Section 4.3.1.2), except that a relatively clean, burnable gas produced from coal is burned instead of natural gas.

The basic gasification process involves crushing the coal and partially oxidizing (i.e., burning) the carbon in the coal. Partial oxidation converts the coal into a gaseous fuel composed primarily of combustible hydrogen and carbon monoxide. The gas can be piped directly into a gas turbine to generate electricity. The exhaust from the gas turbine is ducted into a heat recovery steam generator to produce steam for a conventional steam turbine generator. The combined cycle features of the IGCC plant provide a higher efficiency than either a simple cycle combustion turbine plant or a pulverized coal-fired plant. Higher auxiliary power consumption, primarily by the air separation unit, reduces efficiency below a natural gas-fired combined cycle plant. Sulfur dioxide emissions are quite low due to the high sulfur recovery from the synthesis gas in the sulfur removal process. The low nitrogen content in the synthesis gas, and the use of low NO_x combustion technology in the combustion turbine, limits NO_x emissions to very low levels, as well.

As a means to reduce greenhouse gas emissions, CCS technologies—when they are developed—could be integrated into new fossil-fired power plants including PC, SCPC and IGCC units. A CCS system installed on a PC or SCPC power plant would capture post-combustion gases before they are vented to the atmosphere. The vented gases are passed through a scrubbing system where the CO_2 is absorbed, compressed and transported to storage. A CCS system installed on an IGCC plant would be located before the power generation step, or pre-combustion (PNNL 2009). The CO_2 is absorbed in a similar manner as in the PC plant. A consequence of using CCS technology is higher capital investment and operating costs, whether using PC, SCPC or IGCC technology.

4.3.1.2 Natural Gas

Natural Gas – Existing Generation

Composed mainly of methane, natural gas is a source of fossil energy that results in lower greenhouse gas emissions and most other emissions than power produced by coal-fired plants. TVA has 87 combustion turbines (CT) at nine power plants, with a combined generating capacity of approximately 6,000 MW. TVA also has the capacity to generate up to 890 MW from its Southhaven combined cycle plant and is in the process of completing construction of the 880 MW John Sevier combined cycle plant. The refurbishment of the gas-fired Gleason plant, consisting of three gas-fired combustion turbines, is evaluated as a resource option in the IRP, which increases the available capacity from 360-530 MW. The IRP study also includes the 540 MW Lagoon Creek Combined Cycle Facility, which came online in late summer 2010.

Power purchases from natural gas-fired units owned by independent power producers are also part of the current resource portfolio. TVA is currently party to a long-term lease of a 900 MW combustion turbine plant and has purchased power agreements of over 1,000 MW related to natural gas-fired combined cycle plants.

Natural Gas – New Generation

The IRP evaluation includes both simple and combined cycle natural gas fueled options. In a simple cycle unit, natural gas is used in the fueling of combustion turbines, where it is combusted with air at high pressure and temperature, then expanded to drive a shaft through which shaft work is used to power an electric generator. The major emissions from combustion turbines fired with natural gas are nitrogen oxides (NO_x) and CO_2. To reduce NO_x emissions, dry, low NO_x burners are typically used. Natural gas contains negligible amounts of sulfur, so sulfur dioxide (SO_2) emissions are essentially zero. The higher hydrogen content of the natural gas fuel relative to coal creates lower carbon dioxide (CO_2) emissions on an energy input basis than the emissions from coal-fired power plants.

Several features of simple cycle combustion turbines (CTs), including their relatively low capital cost, short construction times, low emissions and rapid start-up times, make them attractive for generating peaking power during short periods of high demand. Because of their relatively high fuel costs and relatively low efficiency, they are not as well suited for providing intermediate and base load power as combined cycle CTs, pulverized coal plants and nuclear plants. Up to approximately 6000 MW of self-built, TVA-owned simple cycle CT technology for peaking use is evaluated as a resource option.

Combined cycle plants direct the exhaust gas from the combustion turbine of the simple cycle to a heat recovery steam generator, which feeds an additional steam turbine and electric generator. NO_x emissions from the combined cycle combustion turbine can be controlled, and sulfur dioxide emissions from the natural gas fuel are essentially zero. The high efficiency and natural gas fuel combine to produce relatively low CO_2 emissions.

Features of the combined cycle CT option, including its high efficiency, moderate capital cost, relatively high fuel cost, low emissions and short construction time, make this technology a candidate for intermediate capacity additions. Intermediate capacity is expected to operate as required to follow variations in system load. Depending on system load, intermediate capacity may shutdown at night and during weekends, when demand for power is relatively low. Resource options evaluated in the IRP include procurement of power from existing merchant combined cycle plants along with self-built TVA or customer-owned combined cycle plants of up to 1730 MW without specific site locations.

4.3.1.3 Petroleum Fuels

Currently, TVA contracts for a number of diesel fuel generated power purchases, totaling 120 MW, that are expected to be phased out by 2029. There are no diesel fuels or other petroleum based resource options as a primary fuel source under consideration in the IRP because of emissions from these types of facilities.

4.3.2 Nuclear Generation

Nuclear – Existing Generation

The capacity of TVA's existing nuclear units is 6,900 MW, which includes three reactors at TVA's Browns Ferry Nuclear Plant, two at Sequoyah Nuclear Plant, and one at Watts Bar Nuclear Plant. On August 1, 2007, the TVA Board approved the completion of the 1150 MW Unit 2 at the Watts Bar Nuclear Plant. The project is included as a current resource in TVA's generating portfolio and is scheduled for completion in the fall of 2012.

Moreover, the NRC has approved power uprates for TVA's Browns Ferry, Sequoyah and Watts Bar plants since 1998, and additional uprates for its Browns Ferry units are incorporated into the forecast of the capacity of existing resources.

Nuclear – New Generation

TVA has included Bellefonte Units 1 and 2 as well as Units 3 and 4 in the IRP evaluation. In addition to the four Bellefonte units, a non-site specific option based on the Advanced Passive 1000 reactor is also included in the IRP.

Located at the Bellefonte site in northeast Alabama, Bellefonte Units 1 and 2 are the two partially completed Babcock and Wilcox (B&W) pressurized light water reactors with a capacity of 1,260 MW each. Preliminary construction on the Bellefonte site was started in 1974, but construction activities were deferred, with plant systems being maintained to allow reactivation on a schedule to meet future power requirements. On March 9, 2009, the NRC issued an order reinstating the construction permits for Bellefonte Units 1 and 2. Reinstatement of the construction permits, however, does not mean TVA can re-commence construction of these units. Before construction activities can resume, further action by the NRC is required, the contentions that have been filed concerning the resumption of construction must be resolved, and the TVA Board must approve the project. On August 20, 2010, the TVA Board approved funding for additional engineering, design and other activities at Unit 1 to maintain its feasibility as a resource option in the 2018-2019 time period. It is anticipated that the Board will be asked to approve re-commencement of the construction at Unit 1 depending on the outcome of this IRP in spring 2011. The completion of the first unit at Bellefonte, if approved, is expected to take eight years. The second unit at Bellefonte should take six years to complete, assuming the first unit is finished. The lifetime of the units is expected to be at least 40 years. A separate Bellefonte supplemental environmental impact study (SEIS) under NEPA was completed on locating one nuclear unit on the Bellefonte site.

In October 2007, TVA submitted a Combined Construction and Operating License Application to the NRC for two new Westinghouse Electric Co. designed Advanced Passive 1000 reactors. These reactors are to be located at the Bellefonte site and designated as Bellefonte Units 3 and 4 to demonstrate the feasibility of NRC's then new combined construction and operation licensing process. TVA's application was being supported, in part, by NuStart, an industry consortium comprised of 10 utilities and two reactor vendors whose purpose is to satisfactorily demonstrate the new NRC licensing process for new nuclear plants. The Bellefonte Combined Construction and Operating License Application is one of several Advanced Passive 1000 Westinghouse standardized plant applications, and other applicants have announced construction schedules that call for their license reviews to be completed prior to Bellefonte's. As a result, NuStart, with TVA's agreement, is transitioning its reference plant to the Combined Construction and Operating License Application of another utility. TVA has not proposed to add these units to the Bellefonte site, but TVA plans to continue to support the review of the Bellefonte application and does not expect this transition, by itself, to impact the issuance of a license for Bellefonte Units 3 and 4. Contentions have been filed with respect to the Bellefonte Combined Construction and Operating License Application.

4.3.3 Renewable Generation

TVA presently provides renewable energy from TVA facilities and acquired by PPAs generated by hydroelectric, solar, wind and biomass-fueled facilities. As described below, renewable energy from these sources is considered in the IRP. Geothermal energy is not considered because it is not available in or near the TVA region.

4.3.3.1 Hydroelectric

Hydroelectric – Existing Generation

TVA operates conventional hydroelectric generating facilities at 29 of its dams. These facilities have the capacity to generate 3,538 MW of electricity. TVA is also systematically updating aging turbines and other equipment in its powerhouses. The major benefit of this hydro modernization effort is the generation of more power from the same amount of water. Modernization projects that already are approved are included in the forecast of TVA's current hydro resources. TVA also has purchases output from approximately 690 MW of hydroelectric facilities located in the Tennessee Valley, but owned and operated by other parties.

Hydroelectric generation is often considered to be renewable because the fuel, water, is essentially infinite and its availability is determined by the watershed's rainfall and runoff patterns. Hydropower helps to improve air quality by making it possible to burn less coal, oil and gas—technologies that release carbon dioxide into the air. In addition, hydroelectric generation can be dispatched, meaning it can be turned on and off, as long as sufficient water is present. This allows TVA fossil and nuclear units to operate at maximum efficient capacity and minimizes the need to reduce their output to match power needs during hours of the day when demand for electricity is lower.

The operating cost of hydroelectric generation is also very low compared to most other generation sources. TVA has taken many steps to improve the operation of its hydroelectric plants in recent years. These include the implementation of an aggressive Reservoir Releases Improvement program in the early 1990s, which is continuing today. As part of this program, TVA installed equipment and made operational changes to improve the quality of the water as well as the associated fish and invertebrate populations in the tailwater river sections downstream of its dams. Additional operational changes were made in 2004 as a result of the Reservoir Operations Study.

Hydroelectric – New Generation

TVA included additional as-yet-unapproved modernization projects (a total of 90 MW by 2029) as a resource option for its IRP evaluation. TVA also included small- and low-head hydropower as an IRP resource option.

A Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) study (DOE 2006) estimated the amount of additional hydropower resources that are feasible for development within the TVA region. The EERE report estimates the annual average power available for development and, of that available amount, how much would be feasible to develop. Using average capacity factors, this total feasible hydropower capacity is estimated at 1770 MW. None of the feasible capacity is categorized as large power sources (greater than 60 MW). 70% of the feasible capacity was categorized as small hydro (less than 60 MW and greater than 2 MW), and 30% was low power resources (less than 2 MW). Low power resources include conventional technology, ultra low head and kinetic energy turbines, and micro-hydro power. TVA included up to 144 MW of small hydro by 2029 as a resource option evaluated in the IRP.

See Section 4.3.4 on energy storage for discussion of pumped-storage hydropower resource options.

4.3.3.2 Wind

Wind – Existing Facilities

TVA currently owns a 3-turbine, 2-MW wind farm. It has also entered into contracts with third party developers for the long-term purchase of wind power. TVA included the purchase of this wind power through PPAs as a resource option for its IRP evaluation. Depending on the wind resource option, 1330 to 2740 MW (which takes into account transmission delivery losses) of additional wind power will be added by 2029 in the IRP evaluation as purchased power. For reasons discussed below, TVA did not include the self-build options for acquiring additional wind power resources for the TVA generation portfolio.

In mid-2010, TVA began to receive power from the first of what will eventually be a contracted capacity addition (totaling 1380 MW) of wind power to its renewable portfolio through power purchase agreements that resulted from a request for proposals that were issued in December 2008. Iberdrola Renewables began supplying 300 MW from Streator-Cayuga Ridge wind farm in Livingston County, Illinois. Additional wind power agreements exist with Horizon Wind Energy LLC (115 MW starting fall 2010), CPV Renewable Energy Company (365 MW starting 2012), and Invenergy LLC (600 MW starting in 2012).

All new wind contracts were competitive with forecasted market electricity prices at the time those contracts were evaluated. All contracts are contingent on meeting applicable environmental requirements and obtaining firm transmission paths to TVA.

Wind – New Generation

TVA did not include the option of constructing its own wind power facilities in the TVA region, but instead favored the approach of procuring wind power resources through PPAs. As a federal agency, TVA cannot take advantage of the current investment incentives offered to wind power developers. TVA does not have in-house expertise and experience in building and operating wind facilities, and acquiring this expertise is not necessary because the wind industry already has the necessary capability to supply TVA's needs. Overall, the procurement of wind resources, whether in the TVA region or imported to the TVA region, through an RFP process ensures lower cost to TVA customers.

According to a Tennessee Wind Map and Resource Potential estimate from the DOE's Office of Energy Efficiency and Renewable Energy (DOE 2010), approximately 4,200 MW of wind power capacity based on a turbine hub height of 80 meters is available in the TVA service area at a gross capacity factor of 25%. Most current turbine installations have hub heights between 50-80 meters. However, 100-meter hub heights are technically feasible with current wind turbine technology, and taller turbines could help wind power become more economically feasible in low wind areas such as the TVA service area. It is estimated that approximately 57,000 MW of wind power capacity is available in the TVA service area at a turbine hub height of 100 meters.

Taking into account electrical losses, environmental factors and wake effects (of surrounding wind turbines), the net capacity factor for the TVA service area is projected to range from 20-22%, which is on the low end of the typical 20-40% range of net capacity factors for modern utility-scale wind power projects. Taller turbine hub heights do not increase the net capacity factor significantly. The advantages of wind power are no fuel costs, relatively simple design with short lead time for construction and operation, no emissions, and offsetting of greenhouse gases. Disadvantages include limited regional sites with no greater than class 3 wind; turbine siting resistance due to aesthetic, visual and potential noise concerns; and competition for "choice" sites with regional competitors. In addition, wind tends to require additional resources to be built, in the form of energy storage technologies or back up generation resources, in order to provide back-up balancing supply to address the intermittency of wind generation.

4.3.3.3 Solar

Solar – Existing Generation

TVA owns 15 photovoltaic installations with a combined capacity of about 400 kW. TVA also purchases power from photovoltaic installations through the Generation Partners program.

Solar – New Generation

TVA included the purchase of solar power through PPAs as a resource option in its IRP portfolio. TVA did not include the option of constructing its own solar facilities for the same reasons that the construction of wind power facilities was not included (see Section 4.3.3.2).

Generation from solar power is available in two main technologies: concentrating solar power (CSP), also known as solar thermal, and photovoltaic (PV).

1. CSP technologies (i.e., solar thermal plants using parabolic troughs, power tower, etc.) were not evaluated in detail as IRP resource options due to the low rate of delivery of solar radiation within the TVA territory. For example, direct solar radiation in Memphis is approximately 4.4 kilowatt-hour per square meter per day (kWh/m2/day) (NREL 2010), which is below the minimum level of 6.75 kWh/m2/day required for a viable CSP generating facility (Balir 2006).

2. A solar PV cell is made of semiconducting material so that when the sunlight strikes the cell the electrons flow through the material and produce electricity. Thus, there are no moving parts required to generate electricity. Solar PV can make use of both direct solar radiation and diffuse horizontal radiation, which is one reason PV is technically feasible in more areas of the United States than solar thermal technologies. The average solar radiation for PV technology was estimated from National Renewable Energy Laboratory's solar radiation map (NREL 2010) for the western portion of the TVA region to be 4.9 kWh/m2/day. The solar PV capacity factor in the western portion of the TVA service region is calculated at 17%, which is equivalent to approximately four hours of usable solar radiation available each day. TVA included the option of obtaining PPAs for up to 400 MW of solar PV facilities by 2029 as an IRP resource option.

4.3.3.4 Biomass

Biomass – Existing Generation

Biomass power plants use organic matter to generate electricity. It is one of the few renewable power options that can be operated at a relatively high capacity factor (85%) and is "dispatchable," meaning that its generation can be planned and scheduled much like a conventional fossil-fueled unit. TVA is currently performing biomass fuel availability surveys in the region, and a comprehensive study is underway to assess the feasibility of converting one or more coal-burning units to biomass fuel. In addition, TVA generates electricity by co-firing methane from a nearby sewage treatment plant at Allen Fossil Plant and by co-firing wood waste at Colbert Fossil Plant. TVA presently purchases about 91 MW of biomass-fueled generation. These purchases include 9.6 MW of landfill gas generation, 70 MW of wood waste generation and 11 MW of corn milling residue generation.

Biomass – New Generation

TVA included up to 500 MW of biomass generated PPAs and landfill gas generated PPAs as resource options to be evaluated in the IRP. TVA also included the conversion of existing coal-fired units to biomass-fired units and co-firing biomass with coal at existing coal-fired units as IRP resource options to be evaluated. Conversion of existing coal-fired units to biomass or co-firing with coal does not add capacity to these units. For reasons discussed below, TVA did not include the resource option of using municipal solid waste as a fuel.

Agricultural and forest resources provide the most prevalent form of biomass fuel available in the TVA region. These include agricultural “crop” residues (i.e., by-products of harvest), dedicated energy crops (e.g., switchgrass on Conservation Reserve Program [CRP] lands), forest residues (i.e., waste products from logging operations) and methane gas by-products from livestock manure. Biomass resources, such as primary milling residues (i.e., by-products of commercial mills), secondary milling residues (i.e., by-products of woodworking and furniture shops), urban wood residues (i.e., waste wood products from construction, demolition and residential), and methane gas by-products from landfills and wastewater treatment facilities are being considered but are not as prevalent in less densely populated regions such as the TVA service territory.

Stoker grate technology is well proven in the biomass power generation industry and is commercially available. Stoker grate technology is effective in burning solid fuels that contain fuel particles of sufficient size that they must rest on a grate to burn as well as finely sized particles. Solid fuel is introduced into the furnace using pneumatic or mechanical spreaders, which “stokes” (feeds) the furnace (EPRI 2009).

Fluidized bed combustion (FBC) systems have been commercially available for over 20 years in the United States and for longer abroad. Biomass fuels have been successfully fired on many of these units. FBC systems operate on the fluidization process, which begins with a bed of solid granular particles, such as sand or limestone, suspended by an upward flow of air or gas. Combustion temperature is lower than the conventional boiler, which reduces nitrogen oxide production (EPRI 2009). Typical stoker boiler or fluidized bed systems are about 50 MW and can be operated at a capacity factor of about 80%.

A form of small-scale base load power is landfill gas. The natural decay of biomass in landfills produces methane, which can be captured and used in generators for power production. This also reduces the release of methane into the atmosphere. Methane can also be produced from biomass through a process called anaerobic digestion as in wastewater treatment lagoons. Natural bacteria are used to decompose organic matter in the absence of oxygen, producing methane-rich biogas, which is used to produce electricity in a generator. The benefits of utilizing landfill gas are the conversion of waste materials into usable form of energy and the reduction of emissions of potent greenhouse gases. Disadvantages include the limited transmission line availability and uncertain quantity of gas from landfill, causing an uncertain plant lifetime. Because of the small scale, TVA included the landfill gas PPAs as a resource option in the IRP evaluation.

Municipal solid waste (MSW) contains organic materials that can be combusted to produce power. Availability is located in mostly urban centers where waste is collected and sorted to remove non-combustible materials. TVA considers this resource option to be limited due to low availability of waste materials and complexity and uncertainty of emissions. Therefore, TVA has not included fuel by MSW as a resource option in the IRP evaluation.

4.3.4 Energy Storage

An energy storage facility has the ability to store off-peak energy from renewable resources and low cost, off-peak energy from hydropower and thermal resources. This provides significant benefit during periods of low load, when many utilities struggle to meet their system minimum load due to the inability of on-line base load or intermediate resources to reduce generation. The energy stored is then used to provide generation during high peak demand periods. As an additional benefit, availability of an energy storage facility allows on-line resources to operate at a more efficient operating level throughout the day by reducing the range between minimum and peak load.

Energy Storage – Existing Generation

TVA operates one large energy storage facility, the 1615 MW Raccoon Mountain Pumped-Storage Plant. In pumped-hydro storage, water is pumped from a lower reservoir to the upper reservoir using off-peak power. During the generating cycle, water is discharged from the upper reservoir through the reversible pump/turbine-generators located in an underground powerhouse. Pumped-hydro storage facilities have relatively long storage times of 10-20 hours compared to other storage technologies. Thus, pumped-storage hydropower can provide intermediate power to the region. The emissions from a pumped-hydro plant are essentially zero. There are, however, emissions associated with the source of the power used during the pumping cycle.

Energy Storage – New Generation

Two pumped hydroelectric storage resource options at capacities of 850 and 960 MW are included in the IRP evaluation. In addition, a compressed air energy storage (CAES) option is further evaluated in this IRP. As discussed below, TVA did not further evaluate any electric battery storage options.

Limited sites can be considered for conventional pumped-hydro installations because of the required elevation difference between the two reservoirs; however, several sites have been identified in the TVA region. More detailed analyses of these sites, including consideration of site-specific impacts, would be conducted when TVA proposes such projects.

A compressed air energy storage (CAES) plant operates in two cycles. During periods of relatively low electricity demand when power generation costs are low and/or excess energy is supplied from renewable energy sources (e.g., wind), air can be compressed and stored in an underground reservoir. The equipment is analogous to the compressor used in a combustion turbine, and the process is similar to the pumping and storing of water at a higher elevation in pumped-hydro. Then, during periods of high electricity demand, the pressurized air from the underground reservoir is mixed with a fuel (natural gas), burned, and expanded through a high-pressure turbine to produce power. Thus, a CAES unit can provide peaking or intermediate power. As with pumped-hydro, there may be emissions associated with the source of power used during the pumping cycle. There will also be emissions from the combustion process during the generation cycle.

Based on extensive studies of underground storage in the oil and natural gas industry, several geologies appear to be suitable for air storage: salt domes; aquifers, including depleted natural gas fields; and hard rock. Some of these geologic formations are accessible from the TVA region. Located in Alabama, the McIntosh CAES plant is currently in operation in the U.S. with a nameplate capacity of 110 MW. The option under consideration in the IRP has an installed capacity of 330 MW.

Energy storage via batteries is still in the developmental phase at this time and therefore has high uncertainty and risk for utility scale power generation. In addition, the degree of development is not at a large enough size to support utility-scale power generation. Because of these reasons, TVA did not include electric battery storage in its IRP evaluation.

4.3.5 Energy Efficiency and Demand Response

TVA has an existing portfolio of programs focused on energy efficiency and demand response (EEDR) and has included additional EEDR programs in its IRP evaluation. Energy efficiency programs are designed to promote the use of less energy to provide the same level of energy service. Demand response programs are designed to temporarily reduce a customer's use of electricity, typically during peak periods when demand is highest.

TVA develops its EEDR programs in cooperation with the appropriate committees, staff and executives of the Tennessee Valley Public Power Association (TVPPA) and includes representatives of individual power distributors on the product development teams. The partnership with the power distributors and the TVPPA is critical to the collection of market research data, identification of product needs, development of program designs, market testing of products and the ultimate implementation of EEDR programs. Although many new programs are utilizing the turnkey approach through third-party vendors, the decision on implementation lies with the individual power distributors. Designing programs that clearly benefit all three parties—power distributors, end-use consumers, and TVA—has been and will continue to be the key element to successful implementation. Program benefit estimates include an evaluation of potential distributor participation.

The EEDR targets used in the IRP Planning scenarios reflect the benefit from programs that TVA can implement. They do not consider additional energy efficiencies that are gained from regulation (like CFL mandates) or state statutes (like building code changes) or consumer behavior changes from education. These external, non-TVA driven energy efficiency savings are partially reflected (though not captured separately) in the load/demand forecasts whereas, energy efficiency savings resulting from TVA actions are treated in the IRP as a supply “avoidance” option.

EEDR programs evaluated in the IRP do not include interruptible load contracts totaling about 680 MW of avoided capacity that TVA has with industrial customers to reduce the flow of energy to them during high demand periods. Expansion of these contracts was not reviewed in the planning process because TVA is focusing on the development of time of use pricing products whose anticipated effects are reflected in the load forecast and the amount that interruptible contracts, as currently formulated, might be increased is not significant.

TVA’s approach is to ensures that energy efficiency and demand response programs move toward a self-sustaining future by:

- Stimulating and transforming the marketplace instead of “buying the market” with incentives.
- Supporting development of efficiency standards and regulations.
- Providing incentives for energy efficiency and demand reduction in conjunction with proper pricing signals.
- Enabling automatic metering and direct load control.
- Expanding and supporting cleaner end-use generation.

Energy Efficiency and Demand Response (EEDR) programs are targeted towards residential, commercial and industrial customers and offer potential ways to help TVA manage energy consumption and the growth in peak demand. Since the 1970s, TVA has had residential, commercial, and industrial programs to reduce peak demand and energy consumption. As currently implemented, TVA's EEDR portfolio focuses on reduction in peak demand and has an avoided peak capacity of about 250 MW.

TVA's experience to date is that successful energy efficiency programs are highly dependent on the end users' recognition of the cost effectiveness of efficiency. TVA recognizes the important role energy efficiency plays in shaping the load balance and is committed to building EEDR programs for their important resource potential. As part of the Integrated Resource Planning process, TVA has developed program initiatives to focus on reducing energy consumption as well as decreasing peak demand.

Accumulation of benefits from EEDR programs is dependent on factors such as the participation rate of the program, development of implementation infrastructure, and participant economics. Estimates of participation rates in the program designs by both power distributors and end-users are based on past program experience, market analysis, and financial assessment of incentives. Thirty-plus years of DSM program experience with power distributors have shown that no design receives universal acceptance; however, programs designed to provide benefits to TVA, power distributors and end-users will receive significant levels of adoption by power distributors if administrative burden can be minimized. No program design assumes full participation of all distributors.

Participation rates for end-users are based on experience with similar products, analysis of potential eligible consumers, market research on consumer interest, and analysis of participant economic drivers. Incentive rates are calculated to decrease any financial burden to an acceptable level commensurate with the savings to the participant. Focus groups and market research surveys are utilized to identify financial and other motivations to move potential program participants. All programs do not rely solely on cash incentives, but may include a mixture of needed services or information along with financial considerations such as incentives or loans. External economic conditions, however, can produce unanticipated variation in participation requiring mid-stream correction incentive levels, advertising or services provided.

Program infrastructure may include staffing by TVA or distributor, third-party resources, and technical support such as databases and websites. Program designs provide for slower adoption rates in the initial years of deployment to permit development of infrastructure and training of staff. In an effort to minimize administrative burden for both TVA and power distributors, designs frequently employ third-party contractors to supply support and prior expertise. Development of independent resources permits a firmer link between performance and cost without the additional burden of staff impacts associated with shifting priorities or significant program changes.

EEDR program designs also address operational risk through a variety of methods. All designs include estimates of measure life and degradation over time, as noted previously, in recognition of the fact that actions taken or equipment installed do not last forever and must be replaced over time. In addition, components of EEDR benefit calculations utilize conservative estimates of the various factors involved. An assessment of the risk associated with projections of benefits from EEDR programs by Huron Consulting judged the methodology used to produce low estimates of overall savings. The TVA supply planning process also includes hedging supply through the purchase of long-term power purchase options. The deployment of a wide variety of program options provides the ability to scale up the focus on one program or target market in response to lower than expected performance in another program.

Figures 4-1 and 4-2 show the benefit from EEDR options on avoided capacity and avoided generation through 2029 for each of the IRP strategies.

Figure 4-1 – Avoided Capacity of EEDR Options

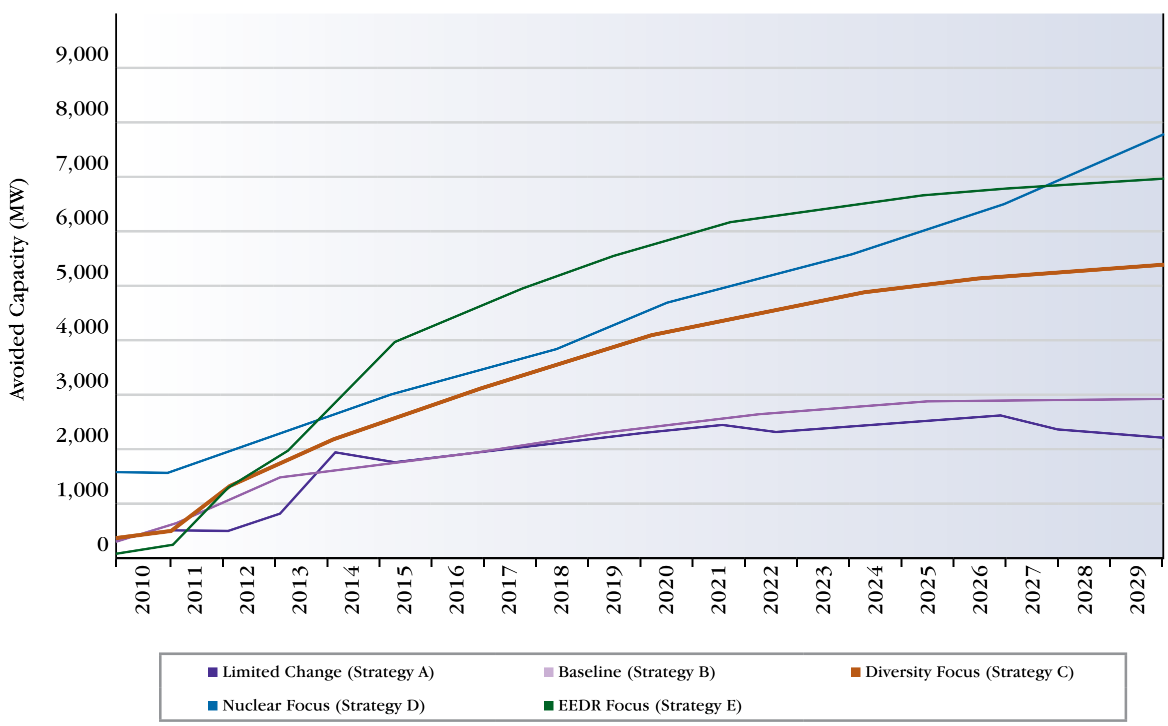
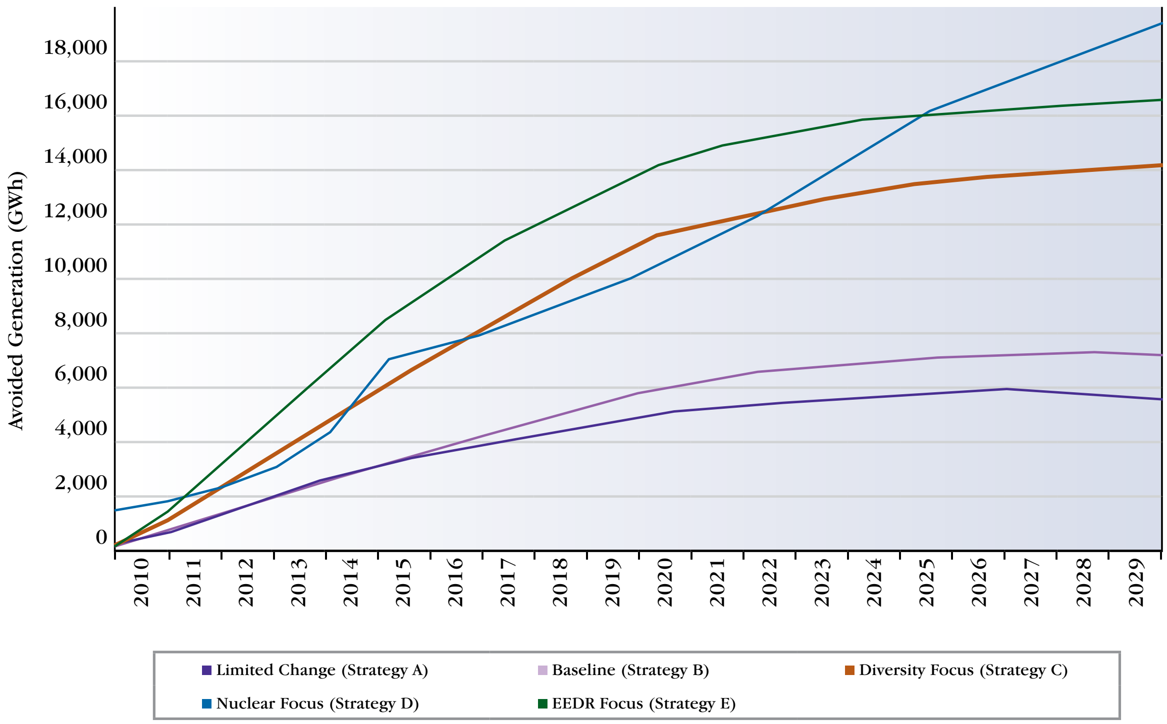


Figure 4-2 – Avoided Generation of EEDR Options



The EEDR options in Figures 4-1 and 4-2 include differing amounts of the following program elements:

- Residential programs for new site-built and manufactured homes, *energy right* home evaluations and in-home energy assessments, heat pump and high-efficiency air conditioning installation and maintenance, and weatherization assistance.
- Commercial and industrial programs providing technical assistance, efficiency advice, incentives, and audits for new and existing facilities.
- Demand response programs for interruptible loads, direct load control and conservation voltage regulation.

This IRP incorporates an EEDR program into the IRP Baseline case and all resource options considered that reflects the energy efficiency that can result from TVA's programmatic efforts. These reductions are in addition to those energy savings that are naturally occurring due to existing laws and policies and the independent programs of its distributors. The IRP Baseline strategy includes an EEDR program that reduces required energy and capacity needs by about 7,300 GWh and 2,900 MW, respectively, by 2029.

Currently available programs include the following:

4.3.5.1 Residential Energy Efficiency

In-Home Energy Evaluation Program – Tests for the new residential program, called the In-Home Energy Evaluation Program, began in 22 markets including Nashville, Chattanooga and the Tri-Cities area (Bristol, Johnson City, and Kingsport) in Tennessee as well as Hopkinsville, Kentucky, and Huntsville, Alabama. The program will offer comprehensive in-home energy audits as well as financing options and incentives to help homeowners who choose to make investments in significant energy efficiency improvements. The homeowner pays for the evaluation, but TVA rebates the evaluation cost to homeowners who have made at least $150 in improvements and had a post-installation inspection. The goal of this program is to educate and motivate the consumer to save energy through improving his or her home. This program was introduced in 2009 and will be available throughout the TVA area by October 2010.

New Homes Program – Provides incentives for builders to construct new homes with increased energy efficiency. Incentives range from $300 to $800 depending on the efficiency of the home. There are three levels of efficiency:

1. Homes built *energy right*® must meet a minimum rating in overall energy efficiency (at least 7% better than standard code requirements).
2. Homes built 15% better than standard qualify as *energy right* Platinum.
3. To qualify for the $800 incentive, *energy right* Platinum certified homes require additional testing at the expense of the builder or homeowner in addition to being 15% better than standard code requirements.

Do-It-Yourself Home Energy Evaluation – Homeowners complete a home energy survey, either online or on a paper form submitted to TVA. The homeowners then receive a personalized report that breaks down their annual and monthly energy usage by category and makes recommendations for increasing energy efficiency. Participants also receive a free energy efficiency kit that may include items such as compact fluorescent light bulbs and gaskets for wall outlets and light switches.

New Manufactured Homes Program – Provides incentives for manufacturers and dealers that install high-efficiency heat pumps in new manufactured homes. Qualifying heat pumps must have a seasonal energy efficiency ratio (SEER) of at least 13 to qualify for a $300/home incentive. TVA is also piloting an ENERGY STAR Manufactured Homes effort with the Manufactured Housing Research Alliance.

Heat Pump Program – TVA promotes the installation of high-efficiency heat pumps in homes and small businesses by providing low-interest, fixed-rate financing for up to 10 years through a third-party lender, with repayment through the consumer's electric bill. TVA has established a Quality Contractor Network of installers meeting high standards. Local distributors, who are reimbursed by TVA for inspection and loan processing/ collection, arrange financing.

4.3.5.2 Commercial and Industrial Energy Efficiency

Commercial Efficiency Advice and Incentives Program – A new initiative targeting businesses and institutions that have 50 kW or greater peak demand that began testing in the Mississippi district and Nashville. This program will offer businesses an opportunity to receive an energy assessment of their facilities to help them identify energy-saving opportunities. Financial incentives of $200 per summer peak kW are also available for projects that help reduce power consumption during TVA's peak period. The goal of the program is to reduce the power demand during TVA's critical peak period.

Major Industrial Program – Targets very large industrial direct-served and distributor-served customers with contract demand greater than 5 MW and offers technical assistance and incentives for energy efficiency projects that lower their demand for power during peak usage periods on the TVA system. Approximately 250 large industrial customers throughout the TVA area are eligible to participate. Participants who implement qualified projects may be eligible for financial incentives of $100 per kW of load reduced during TVA's critical peak period. The goal of this program is to achieve 10% peak demand reduction at each participating facility by 2014.

4.3.5.3 Demand Response

Commercial and Industrial Demand Response – TVA provides incentives to businesses shifting energy-intensive operations from periods of high power demand to periods of lower demand. Participants must be able to achieve a demand response reduction of at least 100 kW and be available for dispatch up to 80 hours per year. Demand reduction events are dispatched and monitored with near-real-time software. Participating customers receive monthly capacity and energy payments based on their performance during demand reduction events.

Conservation Voltage Regulation Program – Uses conservation voltage regulation (CVR) by power distributors to achieve capacity and energy savings through operation of distribution feeders in the lower portion of the ANSI service voltage requirement range, either continuously or on a dispatch-basis.

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Chapter 5 – Resource Plan Development & Analysis

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5 Resource Plan Development and Analysis

5.1 Overview of Scenario Planning

TVA chose to employ a scenario planning approach in the IRP. Scenario planning provides an understanding of how strategic decisions, both immediate and future, would perform under conditions that varied considerably from those considered most likely to occur. For example, we may plan for demand to grow at least 2% per year for the next 10 years, but what if it grows at 4% per year instead? What decisions have we taken that we might regret in that scenario? What decisions can we delay to provide the flexibility to respond? What if demand does not grow at all? Near-term decisions that are common across different scenarios may imply that these decisions are less “risky” since they perform well in most states of the world, whereas major differences in those decisions and the choices implied within those decisions could indicate a high potential for regret in the event of stresses. Scenarios provide a structured framework within which to consider and analyze various supply and demand options in a way that provides decision makers with valuable information about the robustness of those decisions.

Scenarios are different than analytical or quantitative models. Those models focus on what is statistically likely, based largely on historical and/or market data, and operate under the assumption that the future evolves approximately like the past. Scenarios do not represent one specific set of future conditions, nor do they assign probabilities or likelihoods to certain futures arising, but seek only to identify plausible futures that should be studied when developing a long-range resource plan.

In order to provide a planning framework within which specific strategies could be analyzed within the context of the IRP, scenarios were developed to:

- Bind key uncertainties to create a wide range of possible outcomes that would place sufficient stress on each planning strategy.
- Present a set of conditions that were “plausible” – not intended to predict the future but to frame how possible futures *could* unfold.

The design of the scenarios utilized in the 2010 IRP study followed a consistent five-step process shown in the figure below:

Figure 5-1 – TVA Scenario Development Process

- **Document Issue or Decision:** Document how the scenarios will align with the overall IRP development process.
- **Identify Uncertainties to be Evaluated:** Consider regulatory/legislative, economic/financial, social, technological, and other factors. Compare with uncertainties identified by other utilities in recent plans.
- **Identify the Key Uncertainties:** For each uncertainty, consider the range of variation and the relative impact to long-term plans.
- **Develop Scenarios Around Key Uncertainties:** Identify the scenarios that logically result from various combinations of the key uncertainties. For each scenario, create a narrative to be used for planning.
- **Assess Implications of Scenarios:** Ensure that scenarios will be useful in evaluating different business options and “stress” planning decisions.

5.2 Key Uncertainties that Define the Scenarios

Uncertainties are the key drivers that define the scenarios considered in the resource planning process. TVA developed a list of key drivers, or uncertainties, that were used as building blocks to develop scenarios for the IRP. These uncertainties are listed in the figure below:

Figure 5-2 – Key Uncertainties

Key Uncertainty	Description
Greenhouse gas (GHG) requirements	Reflects level of emission reductions (CO_2 and other GHG) mandated by federal legislation plus the cost of carbon allowances.
Environmental outlook	Changes in regulations addressing: • Air emissions (exclusive of GHG) • Land • Water • Waste
Energy Efficiency and Renewable Energy Standards (RES)	Reflects mandates for minimum generation from renewables and the viability of renewable generation sources. It includes the percentage of the RES standard that can be met with Energy Efficiency.
Total load	• Reflects variance of actual load to what is forecast • Accounts for benefits of DSM/EE penetration
Capital expansion viability & costs	For nuclear, fossil, other generation, and transmission, includes risks associated with: • Licensing • Permitting • Project schedule
Financing	• Financial cost (interest rate) of securing capital
Commodity prices	Includes natural gas, coal, oil, uranium, and spot price of electricity.
Contract purchase power cost	Reflects demand cost, availability of power and transmission constraints.
Change in load shape	Includes effects of factors such as: • Time-of-use rates • Plug-in Hybrid Electric Vehicles (transportation) • Distributed generation • Economics changing customer base • Energy storage • Energy efficiency • Smart grid / demand response
Construction cost escalation	Includes the following for nuclear, fossil, and other generation: • Commodity cost escalation • Labor and equipment cost escalation

The final set of scenarios selected for use in the IRP was then further refined to ensure the following characteristics:

- Each scenario is distinct and reflects a plausible, meaningful future world (e.g., uncertainties related to cost, regulation and environment) that TVA could find itself in over the horizon covered in the IRP. Each scenario placed sufficient stress on the resource selection to provide a foundation for analyzing the robustness, flexibility and adaptability of each combination of various supply and demand options (portfolios).
- Captured relevant key stakeholder interests, to the extent possible.

A summary of the six scenarios selected for this IRP study is given in the figure below:

Figure 5-3 – Scenarios Key Characteristics

Scenario	Key Characteristics
1 Economy Recovers Dramatically	• Economy recovers stronger than expected and creates high demand for electricity • Carbon legislation and renewable electricity standards are passed • Demand for commodity and construction resources increases • Electricity prices are moderated by increased gas supply
2 Environmental Focus is a National Priority	• Mitigation of climate change effects and development of a "green economy" is a priority • The cost of CO_2 allowances, gas and electricity increase significantly • Industry focus turns to nuclear, renewables, conservation and gas to meet demand
3 Prolonged Economic Malaise	• Prolonged, stagnant economy results in low to negative load growth and delayed expansion of new generation • Federal climate change legislation is delayed due to concerns of adding further pressure to the economy
4 Game-changing Technology	• Strong economy with high demand for electricity and commodities • High price levels and concerns about the environment incentivize conservation • Game-changing technology results in an abrupt decrease in load served after strong growth
5 Reduce Dependence on Foreign Energy Sources	• The U.S. focuses on reducing its dependence on non-North American fuel sources • Supply of natural gas is constrained and prices for gas and electricity rise • Energy efficiency and renewable energy move to the forefronts as an objective of achieving energy independence
6 Carbon Regulation Creates Economic Downturn	• Federal climate change legislation is passed and implemented quickly • High prices for gas and CO_2 allowances increase electricity prices significantly • U.S. based energy-intensive industry is non-competitive in global markets and leads to an economic downturn

In addition to these six scenarios, the IRP also includes a baseline scenario that closely resembled TVA's long-term planning outlook at the time the original scenarios were developed. For further reference, a detailed description of the seven scenarios used in the study is included at the end of this chapter in Figures 5-10 and 5-11.

In developing specific numerical values for each of the uncertainties that will define each of the scenarios, the following assumptions were used:

- Climate change uncertainty is based upon stringency of requirements, timeline required for compliance and cost of CO_2 allowances.
- An aggressive EPA regulatory schedule is expected to lead to additional compliance requirements (e.g., Hazardous Air Pollutants Maximum Achievable Control Technology (HAPs MACT), revised ambient air standards, etc.).
- Command and control regulation for HAPs MACT will likely drive plant-by-plant compliance.
- Renewable Energy Standards (RES) will help accomplish greenhouse gas reduction as required at the federal level.
- The spot price of electricity will be correlated with the price of natural gas and coal.
- Demand is primarily driven by economic conditions but is also affected by energy efficiency, demand response and other factors.
- Schedule risk is related to demand and uncertainty of permitting and licensing of generation and transmission projects.
- Economic conditions and associated inflationary pressures are the primary drivers for changes in financing costs.
- Construction costs are driven by demand and availability of labor, equipment, design and raw materials. Economic conditions are the primary driver, but the legislative/regulatory environment can apply additional pressure by introducing uncertainty related to potential schedule impacts.
- Cost and availability of contract power purchases are primarily driven by economic conditions and local area demand (i.e., load growth).

5.3 Planning Strategies

Planning strategies are designed to test the various business options and portfolio choices that TVA might consider to determine how each strategy performs when stressed by the scenarios developed. It should be noted that key attributes or elements of each strategy are within TVA's control, and thereby, relevant in making decisions. Also note that this is very different from the scenarios discussed in the previous section, which describe plausible futures, and encompasses factors that are not within of TVA's control. The link is between choice and outcome. The choices TVA makes in developing its portfolio of options for the future (strategy) will be subject to forces outside of TVA's control, and outcomes will be highly dependent on the robustness and the choices made in designing strategies. Poorly developed strategies will not perform well (bad outcomes) whereas robust and well-designed strategies will perform well over many possible futures (good outcomes).

The planning strategies considered in the IRP frame multiple distinct portfolios that are then tested across multiple scenarios. Each alternative portfolio is described by a unique combination of strategic objectives and/or constraints. The objective in the IRP is to identify one or more strategies that provide stability and flexibility over an uncertain long-term future, as well as robust performance across multiple possible worlds. This last objective is closely related to the no-regrets planning framework, and refers to the fact that a good strategy is one that performs relatively well even when the future unfolds in a way that was not foreseen in the baseline forecast.

In developing the planning strategies, TVA identified nine distinct categories of attributes to describe them. The choice of attributes was influenced by comments received during the public scoping and focused on those assumptions that would have the greatest impact on the options that might be included in the long-term resource plan. These attributes fall into one of two groups:

1. **Defined Model Inputs**: Attributes that are scheduled or pre-determined. These can refer to the timing of technology of specific asset decisions like the online date of a new natural gas plant. The capacity optimization model selects a resource portfolio that presumes these resources already exist and plans around these options.

2. **Constraints in the Model Optimization**: Attributes that constrain the optimization of asset choices include minimum build times, technology limitations, and other strategic constraints including limits on market purchases. The capacity optimization model will identify a solution (resource portfolio) that is consistent with these constraints.

The attributes for the planning strategies are described in the following figure:

Figure 5-4 – Attributes of Planning Strategies

Attribute	Description	Type
EEDR Portfolio	The level of energy efficiency (EE) and demand response (DR) included in each strategy.	Defined Model Input
Renewable Additions	The amount of renewable resources added in each strategy.	Defined Model Input
Fossil Asset Layups	A proposed schedule of coal unit layups that will be tested in each strategy.	Defined Model Input
Energy Storage	Option to include a pumped-storage hydro unit in selected strategies.	Defined Model Input
Nuclear	Constraints related to the addition of new nuclear capacity.	Constraint
Coal	Limitations on technology and timing for new coal-fired plants.	Constraint
Gas-Fired Supply (Self Build)	Limitations on gas-fired unit expansion.	Constraint
Market Purchases	Level of market reliance allowed in each strategy.	Constraint
Transmission	Type and level of transmission infrastructure required to support resource options in each strategy.	Constraint

TVA combined these nine attributes to create five distinct planning strategies for examination in the IRP study. Those strategies are:

Figure 5-5 – Planning Strategies Key Characteristics

Planning Strategy	Key Characteristics
A Limited Change in Current Resource Portfolio	• Retain and maintain existing generating fleet (no additions beyond Watts Bar 2) • Rely on the market to meet future resource needs
B Baseline Plan Resource Portfolio	• Allows for nuclear expansion after 2018 and new gas-fired capacity as needed • Assumes idling of 2000 MW of coal capacity • Includes EEDR portfolios and wind PPA's
C Diversity Focused Resource Portfolio	• Allows for nuclear expansion after 2018 and new gas-fired capacity as needed • Increases the contribution from EEDR portfolio and new renewables • Adds a pumped-storage hydro unit • Assumes idling of 3000 MW of coal capacity
D Nuclear Focused Resource Portfolio	• Allows for nuclear expansion after 2018 and new gas-fired capacity as needed • Includes an increased EEDR portfolio compared to other strategies • Assumes idling of 7000 MW of coal capacity • Includes new renewables (same as planning Strategy C) • Includes a pumped-storage hydro unit
E EEDR and Renewables Focused Resource Portfolio	• Assumes greatest reliance on EEDR portfolio of any strategy and includes largest new renewable portfolio • Assumes idling of 5000 MW of coal capacity • Delays nuclear expansion until 2022

A more detailed description of the planning strategies is shown at the end of this chapter in Figure 5-12 with defined model inputs shown with highlighted background.

5.4 Portfolio Development

In order to guide planning decisions, TVA develops sets or portfolios of assets made up of various generating technologies and cost characteristics. To do so, TVA employs a complex mathematical technique known as optimization, where an "objective function" (in this case, total cost) is minimized subject to a number of constraints (with the most important being balancing supply and demand). The technical term for the optimization technique applied is *mixed integer linear programming*. Each planning strategy is "optimized" for each of the seven scenarios, with the end result being a set of 35 distinct portfolios made up of optimized variants of each planning strategy in all seven worlds. Given the nature of the analysis, certain elements of the strategy are the same across worlds (i.e. emphasis on EEDR, reliance on nuclear energy), while others (amount of natural gas-fired capacity, market purchases) are a function of the interplay between each planning strategy and the world within which it is analyzed.

As described above, TVA employs a form of mathematical analysis known as optimization to design portfolios within each world. TVA utilizes an industry standard software model developed by Ventyx known as System Optimizer. System Optimizer works by adding or subtracting assets into a portfolio based on minimizing the Present Value of Revenue Requirements (PVRR) subject to the following constraints:

- Energy Balance
- Reserve Margin
- Generation and Transmission Operating Limits
- Fuel Purchase and Utilization Limits
- Environmental Stewardship

The model generates multiple combinations of resources for each year of the study period and computes the costs of each combination. Capital costs for supply-side options are amortized for investment recovery using a real economic carrying cost method that accounts for the unequal economic lives of generating assets and ensure that assets with higher capital costs, but longer service lives, are not unduly penalized relative to assets with lower capital costs but relatively shorter economic lives.

Capacity optimization tools like System Optimizer use a simplified dispatch algorithm to compute production costs because of the number of possible states evaluated. The model uses a "representative hours" approach, in which average generation and load values in each representative period in a week are scaled up appropriately to span all hours of the week and days of the months.

Year-to-year changes in resource mix are then evaluated and infeasible “states” are eliminated. The least cost (i.e., lowest PVRR) path through the possible states in the study period is retained as the optimized capacity plan.

Each of the 35 portfolios is also evaluated using an hourly production costing algorithm that calculates detailed production costs of each portfolio after accounting for fuel and other variable operating costs. These detailed cost simulations provide total strategy costs and financial metrics that are then used to rank and select the preferred planning strategy. This analysis is accomplished using another Ventyx product called Strategic Planning (MIDAS). This software tool uses a chronological production costing algorithm and includes financial planning data that can be used to assess plan cost, system rate impacts, and financial risk by utilizing a variant of Monte Carlo analysis; a sophisticated analytical technique that varies important drivers and creates a distribution of total costs, rather than a single point estimate, to allow for risk analysis. The Monte Carlo (also known as stochastic) analysis in MIDAS uses 13 key variables and allows for random walking of values in the Monte Carlo algorithm.

The variables selected by TVA for this analysis include:

- Commodity Prices – natural gas, coal, CO_2 allowances, SO_2 and NO_x allowances
- Financial Parameters – interest rates and electricity prices
- Operating Costs – capital and O&M
- Dispatch Costs – hydro generation, fossil and nuclear availability
- Load Forecast Uncertainty

The Monte Carlo analysis employs 72 iterations to describe the uncertainty associated with each of the portfolios created by the capacity optimization model. The expected value for the PVRR and short-term rates from these stochastic iterations represent the costs associated with each portfolio.

5.5 The Planning Strategy Scorecard

The identification of a preferred planning strategy involves a trade-off analysis that focuses on multiple metrics of cost, risk, environmental impacts and other aspects of TVA’s overall mission. A strategy scorecard is used to facilitate this trade-off analysis. A scorecard template is shown in Figure 5-6 and is comprised of two sections: (1.) ranking metrics and (2.) strategic metrics:

Figure 5-6 – Planning Strategy Scorecard

	RANKING METRICS		
	Energy Supply		
Portfolios	Cost	Risk	Ranking Metric Score
		Total Score:	

STRATEGIC METRICS				
Environmental Stewardship			Economic Development	
Carbon Footprint	Water Impact	Waste Impact	Total Employment	Growth in Personal Income

In addition to the scorecard, a technology innovation narrative is also included, which is discussed in section 5.5.3.

5.5.1 Ranking Metrics

Ranking metrics are financial measures of cost and risk that are used to apply quantitative rankings to the planning strategies. The IRP study uses cost and risk metrics to identify the preferred planning strategy.

5.5.1.1 Plan Cost Metrics

The plan cost metric is a combination of both a PVRR metric and a short-term rate metric. The PVRR metric is the cumulative present value of total revenue requirements over the study period based on an 8% discount rate.

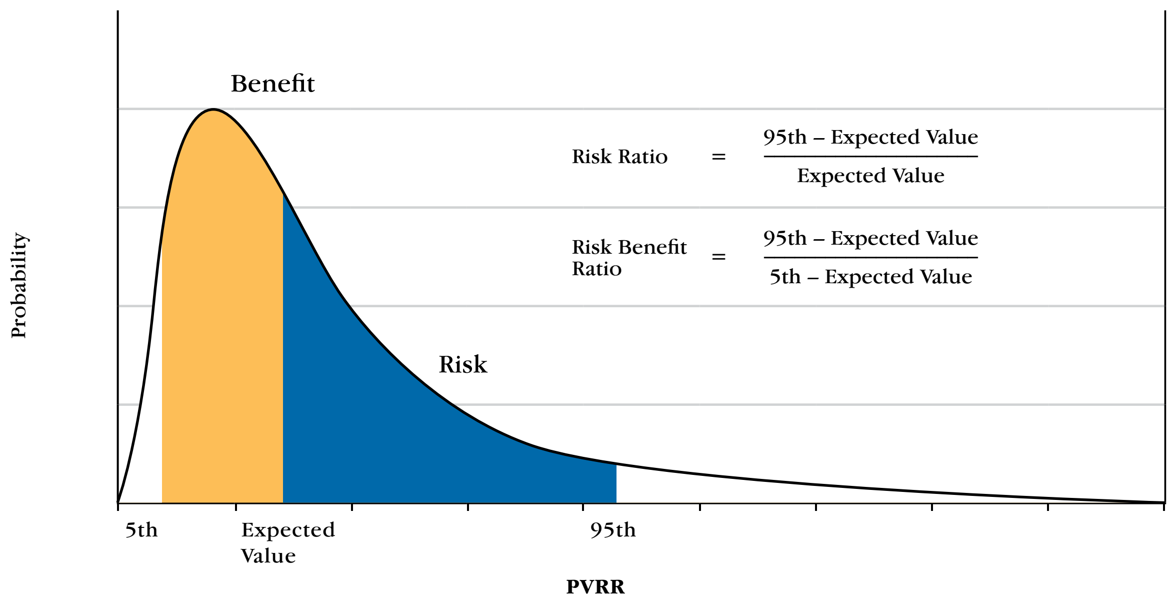
The short-term rate metric provides an alternative representation of the revenue requirements for the period 2011-2018 expressed per MWh. This metric was developed to focus on the near-term impacts to system cost in recognition of TVA's current debt cap of $30 billion and the likelihood that a majority of capital expenditures in the short term (prior to 2018) may have to be funded solely from rates.

By considering both PVRR and short-term rates, TVA is better able to evaluate the cost implications for various portfolios. Including both short-term and total revenue requirements facilitates a trade-off analysis of alternative resource plans, and allows TVA to more explicitly evaluate funding implications, consistent with stakeholder concerns about increasing rate pressures (see discussion in Section 2.2.5). The expected values for PVRR and short-term rates generated by the stochastic analysis are used to compare portfolios.

5.5.1.2 Financial Risk Metrics

PVRR risk metrics are also computed for each of the portfolios. Two indicators are used: a risk ratio and a risk/benefit ratio. Figure 5-7 provides a graphical explanation of how these risk ratios are computed:

Figure 5-7 – Financial Risk Metrics



The risk score for each portfolio is a combination of risk ratio and risk/benefit ratio. The risk ratio is represented by the potential of exceeding the expected PVRR and is similar to the Value at Risk technique used to capture risks in the financial sector. The risk/benefit ratio measures the potential of exceeding the expected PVRR but compares it to the benefit of not exceeding the expected PVRR expressed as a ratio. In other words, it compares the potential risks of a strategy with the potential benefits of that strategy to determine whether or not the "risks and rewards" balance is tipped in favor of the customer.

Each of these ranking metrics is based on a weighted formula:

Cost Metric = 0.65 * PVRR + 0.35 * short-term rates

Risk Metric = 0.65 * risk ratio + 0.35 * risk/benefit ratio

Ranking Metrics Score = 0.65 * cost + 0.35 * risk

5.5.2 Strategic Metrics

Strategic Metrics are paired with ranking metrics to complete the IRP scorecard for selection of preferred strategies.

5.5.2.1 Environmental Stewardship Strategic Metric

The environmental strategic metric was developed to evaluate air, water and waste impacts. In evaluating the air metric CO_2, sulfur dioxide, nitrogen oxide emissions, and mercury were calculated for each case. Emission trends for the later three emissions were steeply reduced as all cases assumed large plant layups (2000-7000 MW) or highly controlled (90% or better emission removal rates) operating units in the future. In all cases, these emissions all tracked similar trend lines for CO_2. Thus the air metric is represented as a CO_2 impact "footprint" factor (annual average tons).

Air Impact = Annual average tons of CO_2 emitted

All emission trends follow the same declining pattern, and no additional information was provided using all air emissions as opposed to CO_2 only. Costs associated with CO_2 emissions are included in all scenarios and are reflected in the PVRR for all the portfolios (see Figure 5-10).

The water component of the environmental strategic metric uses the thermal load produced through the condenser cooling cycle from steam generating plants as a measure of thermal impacts to the environment. The water impact is estimated based on the total heat dissipated by the condenser, expressed in BTUs, in the generation cooling cycle. The formula for the water impact is:

Water Impact = Generation by fuel type (GWH) x heat input x design factor

Design factors for the various generation sources expected to impact water (primarily fossil and nuclear) were based on actual data from the TVA fleet (averaged) or the design manufacturer's performance information for expected heat losses to the condenser.

In addition to air and water impacts, certain generation sources produce waste streams that require disposal. The waste component used in this analysis only focused on waste streams from coal and nuclear generation. The volumetric and disposal costs are used to better normalize for differences in mass generated (tons). Waste streams estimated include coal ash (fly and bottom ash), FGD/scrubber waste, and high- and low-level nuclear waste. The formula for the waste impact is:

Waste Impact = Fuel consumed (mmBTU) x waste factor x handling costs ($/ton)

Waste factors for coal ash were based on 2009 weighted coal laboratory analysis for the average heat content (BTU/lb) across the six coal basins that TVA purchases from and a weighted average ash percentage (also based on the 2009 coal basins analysis data). Separate weighted averages were calculated for each strategy to better reflect the fossil layup assumptions (0-7000 MW). The other sources of waste from coal plants are flue gas desulfurization controls, also known as scrubbers. Scrubbers aid in the removal of sulfur dioxide emissions, but produce calcium sulfate, or gypsum, as a by-product. The waste factor applied to scrubbers is based on historical average performance for the TVA scrubbed fleet, assuming current percentages (approximately 50%) of the TVA fleet is scrubbed in 2010. For future year calculations, it was assumed that all remaining TVA coal generation (based on fossil layup assumptions) are scrubbed.

Results for all coal waste streams were converted to tons and then multiplied by handling costs ($/ton) to compare to nuclear waste. It should be noted that the assumptions for coal waste generation are considered conservative since future scrubbers (dry) would be combined with other control technologies to capture the fly ash portion of coal ash in their waste stream, although they are represented in this calculation separately. Calculations also do not represent utilization of coal waste products for beneficial uses.

Like coal waste, nuclear waste streams are based on averages across TVA's existing six units and converted to tons and then multiplied by handling costs ($/ton) for comparison.

5.5.2.2 – Economic Development Metric

Economic metrics are included to provide an indication of the impact of each strategy on the general economic conditions in the TVA service area, represented by total employment and personal income indicators, as compared to the impacts that would be realized under Strategy B (Baseline Plan Resource Portfolio) in Scenario 7.

The IRP study defined economic impact as growth in regional economic activity. Measurement criteria include total personal income in "constant" dollars (i.e., with inflation accounted for) and total employment. These provide measures for the effects of the various planning strategies on the overall, long-term health or welfare of the economy for the next 20 years. This analysis concentrates on changes to the welfare of the overall economy due to the strategies. It does not address changes to the distribution of income or employment.

Two types of factors associated with the portfolios produced by a particular strategy in a given scenario affect the regional economic impact metrics:

1. Direct expenditures for labor and materials incurred in the Tennessee Valley during the construction and operation phases of an energy resource option.
2. Changes to the electricity bills of end-use customers of TVA electricity as a result of increased or decreased costs from the implementation of a particular portfolio (changes could be caused either by TVA rates or energy efficiency).

In general, the greater the direct regional expenditures associated with a particular portfolio, the more positive are the effects on regional economic development. This can be offset, however, by the fact that higher rates caused by higher costs have a negative effect on regional economic development. Thus, a resource portfolio that has high expenditures in the Tennessee Valley compared to other portfolios may also have high costs and high rates. The overall effect on the economic impact metrics for a particular planning strategy may be positive or negative depending on the net sum of the expenditure effects and the cost effects. More details about the methodology used to determine the economic impact metrics for the planning strategies can be found in Appendix B.

5.5.3 Technology Innovations Narrative

In addition to the ranking metrics and strategic metrics, a brief narrative that discusses the technology innovations associated with each planning strategy will be prepared (see Chapter 7) to provide the TVA Board with an insight into the technology utilization implicit in each strategy. This narrative is not a metric, but will be included along with the fully populated scorecard as background information that could be considered when selecting a preferred planning strategy. The technology innovation narrative will discuss what technologies would require investment to enable the resource mix identified in each strategy (e.g., a planning strategy with extensive EEDR may need smart grid investments for energy savings to be fully realized).

5.6 Scorecard Calculation and Color Coding

The ranking metrics in the scorecard are expressed in terms of a 100-point score by translating the metric values while ensuring that the relative relationship between the actual values for each portfolio in the strategy is maintained. The process of computing the scores is:

- Actual values of ranking metrics (e.g., PVRR, short-term rate impacts) will be converted to a unit less score on a 100-point scale. Using this type of scoring helps to assess and prioritize risk to find the best possible solution.
- The highest ranking ("best") value will receive 100.
- The rest of the scores will be based on their relative position to the "best" value (i.e., a value that is 75% of the "best" would receive a 75).
- A color-coding method is used to assist in visual comparison of portfolio results. The coding is done within a given scenario. The "best" value for each metric is coded green; the "worst" value is coded red; and the values in between are shown with a shaded color that corresponds to the relationship of the score values.

An example of how this translation from actual values to ranking metric score is shown in Figure 5-8 (this example shows the conversion for the short-term rate metric):

Figure 5-8 – Ranking Metrics Example

Raw ranking metric value for short term rate impacts in scenario 1 are shown to right.

Ranking Metric Scores		
	Strategy	Scenario 1
Average of ST Rates $/MWh (level 2011-18)	A	76.82
	B	78.67
	C	79.95
	D	84.61
	E	80.41

The "best" (in this case lowest) value within a scenario gets a score of 100

Strategy D is 10.13% higher than the "best" value and receives a score of 89.97

Scores are converted from the raw scores as shown and are included in the planning strategy score cards

Converted Ranking Metric Scores		
	Strategy	Scenario 1
Average of ST Rates $/MWh (level 2011-18)	A	100.00
	B	97.59
	C	95.93
	D	89.97
	E	95.34

All other scores are assigned a value based on their relative position to the "best" score

The strategic metrics are included in the scorecard in two ways: for environmental stewardship metrics, metric values are translated into a relative scoring system known as a Harvey Ball rating system, and the economic impact metrics are represented by a percent change from a reference case. For the environmental metrics, in a given scenario the data are coded so that the relative relationship (rank order) among the strategies is indicated by the amount of the ball that is filled in. An example of how this translation is done is shown in Figure 5-9 on the following page.

Figure 5-9 – Example Scoring Process – Carbon Footprint

- The following is an example of how the "Harvey Ball" ratings will be applied to the Carbon Footprint strategic metric
- Expected values for annual CO_2 emissions from stochastic analysis are shown to the right

Average Annual CO_2 Emissions (Million Tons)

	Scenarios						
Strategy	1	2	3	4	5	6	7
A	2,054	1,719	1,402	1,775	1,723	1,190	1,767
B	1,774	1,461	1,317	1,518	1,480	1,138	1,533
C	1,673	1,418	1,210	1,408	1,422	1,035	1,427
D	1,468	1,170	1,058	1,256	1,204	962	1,249
E	1,613	1,299	1,106	1,410	1,303	959	1,352

- Planning strategies are ranked based on their performance within each scenario

  In this example, 1=highest and 5=lowest
- In this example, quantitative data is available to support the ranking, however, other strategic metrics may require qualitative assessment for ranking

Carbon Footprint Rankings Within Scenarios

	Scenarios						
Strategy	1	2	3	4	5	6	7
A	5	5	5	5	5	5	5
B	4	4	4	4	4	4	4
C	3	3	3	2	3	3	3
D	1	1	1	1	1	2	1
E	2	2	2	3	2	1	2

- The appropriate "Harvey Ball' is assigned based on the rankings

Populated Carbon Footprint Strategic Metric

Legend	
●	Better
◕	↑
◑	
◔	
○	

	Scenarios						
Strategy	1	2	3	4	5	6	7
A	○	○	○	○	○	○	○
B	◔	◔	◔	◔	◔	◔	◔
C	◑	◑	◑	◕	◑	◑	◑
D	●	●	●	●	●	◕	●
E	◕	◕	◕	◑	◕	●	◕

For the economic impact metrics, data are included in the scorecard as a percent change from the reference case (Strategy B in Scenario 7). For this draft report, only the range of possible impacts has been evaluated (instead of computing impacts for all 35 portfolios) by computing the values for each planning strategy in Scenario 1 and Scenario 6. The changes in employment and personal income in these scenarios relative to the reference case (Strategy B in Scenario 7) is indicative of the maximum impacts that would result in any of the other scenario/strategy combinations.

5.7 Planning Strategy Evaluation

The scorecard is used to compare planning strategies by computing a score for each of the 35 portfolios evaluated in the study (seven portfolios to describe each of the five planning strategies). Scores are based on the expected value for the cost and risk metrics developed using a stratified Monte Carlo analysis as described in detail above. The ranking metrics are then weighted to compute the total score for each portfolio using the formulas described in the prior section.

Identification of the preferred planning strategy/strategies is accomplished using a three-step process that identifies a strategy or strategies for further evaluation based on the ranking metrics. The identification process is as follows:

Step 1 – Planning strategies are ranked by summing scores (the ranking metrics) for each portfolio that is produced in a given strategy over all scenarios (seven total) – this results in a Total Planning Strategy Score.

- Sensitivity analysis is conducted to refine preliminary results and/or capture other portfolio options. A preferred set of planning strategy alternatives are identified based on the ranking metrics.
- Resource portfolios are then identified from planning strategy alternatives that will serve to define the planning strategies for the purpose of comparative analysis and impact assessment.

Step 2 – Resource portfolios from the planning strategies selected in the prior step are used to define the breadth of options considered in the draft IRP and associated EIS.

- A sufficient number of portfolios will be presented to achieve a broad range of possible strategic options for TVA that maintains resource flexibility and responds to changing future conditions.
- Strategic metrics are combined with the ranking metrics for each of the selected reference resource portfolios to complete the scorecard.
- The initial scorecard is shared publicly during the comment period for the EIS and used to facilitate the discussion of trade-offs. This trade-off assessment is focused on consideration of the scorecard values – cost, risk, and the strategic metrics.

Step 3 – Following completion of a public comment period on the initial results, the identified reference resource portfolios are updated and re-scored. This may include consideration of additional sensitivity cases or alternative scenarios not included in the draft phase.

- The purpose of this additional analysis is to ensure that the basis for the recommendation of one or more planning strategies is not substantially changed due to new or updated information or planning assumptions.
- A short list of reference resource portfolios that enable TVA to implement one or more planning strategies are presented to the Board for consideration.
- The TVA Board sets strategic direction by the strategy or combination of strategies it decides to select.
- An implementing resource plan is identified that best enables TVA to pursue the planning strategy adopted by the Board. This implementing resource plan is subject to refinement based on changing circumstances, or annually as part of the capacity planning cycle.

Chapter 7 includes the results of the capacity planning and production cost modeling and their scores. It also identifies a recommended set of planning strategies for consideration during the public comment period. This study report will be updated following completion of step 3 in the evaluation process.

Figure 5-10 – Scenario Descriptions I

Uncertainty	Scenario 1 Economy Recovers Dramatically	Scenario 2 Environmental Focus is a National Priority	Scenario 3 Prolonged Economic Malaise	Scenario 4 Game-changing Technology	Scenario 5 Energy Independence	Scenario 6 Carbon Legislation Creates Economic Downturn	IRP Base Case
Greenhouse gas requirements	CO_2 price $27/ton ($30/metric ton) in 2014 and $82 ($90/metric ton) by 2030. 77% allowance allocation, 41% by 2030	CO_2 price $17/ton ($19/metric ton) in 2012 and $94 ($104/metric ton) by 2030. 77% allowance allocation, 28% by 2030	No federal requirement (CO_2 price = $0/ton)	CO_2 price $18/ton ($20/metric ton) in 2013 and $45 ($50/metric ton) by 2030. 77% allowance allocation, 41% by 2030	CO_2 price $18/ton ($20/metric ton) in 2013 and $45 ($50/metric ton) by 2030. 77% allowance allocation, 41% by 2030	CO_2 price $17/ton ($19/metric ton) in 2012 and $94 ($104/metric ton) by 2030. 77% allowance allocation, 28% by 2030	CO_2 price $15/ton ($17/metric ton) in 2013 and $56 ($62/metric ton) by 2030. 77% allowance allocation, 39% by 2030
Environmental outlook	Same as Base Case	SO_2 controls 2017 NO_x controls Dec 2016 Hg MACT 2014 HAP MACT 2015	No additional requirements (CAIR requirements, with no MACT requirements)	Same as Base Case	Same as Base Case	Same as Base Case	SCR all units by 2017 FGD all units by 2018 HAPs MACT by 2015
Energy Effiiency (EE) & Renewable Electricity Standards (RES)	RES – 3% by 2012, 20% by 2021 (adjusted total retail sales) EE can meet up to 25% or requirement	RES – 5% by 2012, 30% by 2021 (adjusted total retail sales) EE can meet up to 25% or requirement	No federal requirement	RES – 5% by 2012, 20% by 2021 (adjusted total retail sales) EE can meet up to 40% or requirement	RES – 5% by 2012, 20% by 2021 (adjusted total retail sales) EE can meet up to 40% or requirement	RES – 5% by 2012, 30% by 2021 (adjusted total retail sales) EE can meet up to 25% or requirement	RES – 3% by 2012, 15% by 2021 (adjusted total retail sales) EE can meet up to 25% or requirement
Total load	Med grow to High by 2015; High Dist; Alcoa Returns in 2010+; USEC stays forever; Dpet Dist same as Base	Medium case, then 2012 40% rate increase; Low Dist; DS customer reductions (steel/paper plants); USEC stays forever; Dept Dist same as Base	Low load case; Low Dist; Alcoa not returning, No HSC & Wacker; USEC leaves June 2013; Dept Disc same as Base	Med-High load growth through 2020, then 20% decrease 2021-2022 including USEC departure, reduced dist sales & extended TOU	Medium case, then 20% rate increase in 2014; unrestricted PHEV included; TOU	Medium load case 2010-2011; 2012 low case then flat w/no growth; USEC leaves 2013; Alcoa not returning, HSC & Wacker not in; TOU	Moderate growth
Capital expansion viability & costs	Moderate schedule risk	High schedule risk	Low schedule risk	Moderate schedule risk	Moderate schedule risk	Low schedule risk	Moderate schedule risk

Figure 5-11 – Scenario Descriptions II

Uncertainty	Scenario 1 Economy Recovers Dramatically	Scenario 2 Environmental Focus is a National Priority	Scenario 3 Prolonged Economic Malaise	Scenario 4 Game-changing Technology	Scenario 5 Energy Independence	Scenario 6 Carbon Legislation Creates Economic Downturn	IRP Base Case
Financing	Higher than base case—higher inflation due to higher economic growth	Higher than base case—higher inflation due to looser monetary policy supporting economic growth	Lower than base case—lower inflation due to lower economic growth	Same as base case—increased productivity due to technology leads to stronger economic wealth and non-inflationary money growth	Higher than base case—higher inflation due to looser monetary policy supporting economic growth	Lower than base case—lower inflation due to lower economic growth	Based on current borrowing rate
Commodity prices	Gas & coal higher than base case	Gas higher; coal lower than base case	Gas much lower & coal much higher than base case	Gas lower & coal slightly higher than base case	Gas & coal higher than base case	Gas & coal much lower than base case	Gas - $6-8/ mmBTU Coal - $40/ton
Contract Purchase Power Cost	Much higher cost & lower availability	Higher cost & lower availability	Same as base, then much lower cost with high availability	Higher cost & lower availability, then much lower cost with high availability after load decrease	Higher cost & lower availability	Lower cost with high availability	Moderate cost & availability
Construction Cost Escalation	Much higher than base case—high economic growth causes high demand for new plants and high escalation rate	Somewhat higher than base case—due to "construction costs escalating at high rate due to large volume of nuclear, renewables and env controls projects". High regulatory scrutiny adds to project costs	Lower than base case—low load growth leads to low escalation	This scenario has two stages of escalation: 1) higher than base due to high load growth early, then 2) lower escalation when game-changing technology hits	Somewhat higher than base case—moderately strong economy and load growth leads to somewhat higher than base escalation	Lower than base case—negative load growth, very weak economy and high renewables lead to low escalation	Moderate escalation

Figure 5-12 – Strategy Descriptions

Attributes	Scenario A Limited Change in Current Resource Portfolio	Scenario B Baseline Plan Resource Portfolio	Scenario C Diversity Focused Resource Portfolio	Scenario D Nuclear Focused Resource Portfolio	Scenario E EEDR and Renewable Focused Resource Portfolio
EEDR	1,940 MW & 4.725 annual GWh reductions by 2020 (Iteration 12)	2,100 MW & 5,900 annual GWh reductions by 2020 (FY11 LRFP / 10.75)	3,600 MW & 11,400 annual GWh reductions by 2020 (BLN case / 10.5)	4,000 MW & 8,900 annual GWh reductions by 2020 (based on EPRI)	5,900 MW & 14,400 annual GWh reductions by 2020 (aggresive / 11.1)
Renewable Additions	1,300 MW & 4,600 GWh competitive renewable resources or PPAs by 2020	Same as Planning Strategy A	2,500 MW & 8,600 GWh competitive renewable resources or PPAs by 2020	Same as Planning Strategy C	3,500 MW & 12,000 GWh competitive renewable resources or PPAs by 2020
Fossil Asset Layup	No fossil fleet reductions	2,000 MW total fleet reductions by 2017	3,000 MW total fleet reductions by 2017	7,000 MW total fleet reductions by 2017	5,000 MW total fleet reductions by 2017
Energy Storage	No new additions	Same as Planning Strategy A	Add on pumped-storage unit	Same as Planning Strategy C	Same as Planning Strategy A
Nuclear	No new additions after WBN2	First unit online no earlier than 2018 Units at least 4 years apart	Same as Planning Strategy B	First unit online no earlier than 2018 Units at least 2 years apart	First unit online no earlier than 2022 Units at least 2 years apart Additions limited to 3 units
Coal	No new additions	New coal units are outfitted with CCS First unit online no earlier than 2025	Same as Planning Strategy B	Same as Planning Strategy B	No new additions
Gas-Fired Supply (Self-Build)	No new additions	Meet remaining supply needs with gas-fired units	Same as Planning Strategy B	Same as Planning Strategy B	Same as Planning Strategy B
Market Purchases	No limit on market purchases beyond current contracts and extensions	Purchases beyond current contracts and contract extensions limited to 900 MW	Same as Planning Strategy B	Same as Planning Strategy B	Same as Planning Strategy B
Transmission	Potentially higher level of transmission investment to support market purchases Transmission expansion (if needed) may have impact on resource timing and availability	Complete upgrades to support new supply resources	Increase transmission investment to support new supply resources and ensure system reliability Pursue inter-regional projects to transmit renewable energy	Same as Planning Strategy C	Potentially higher level of transmission investment to support renewable purchases Transmission expansion (if needed) may have impact on resource timing and availability

■ Defined model inputs ☐ Optimized model inputs

Chapter 6 – Resource Plan Results

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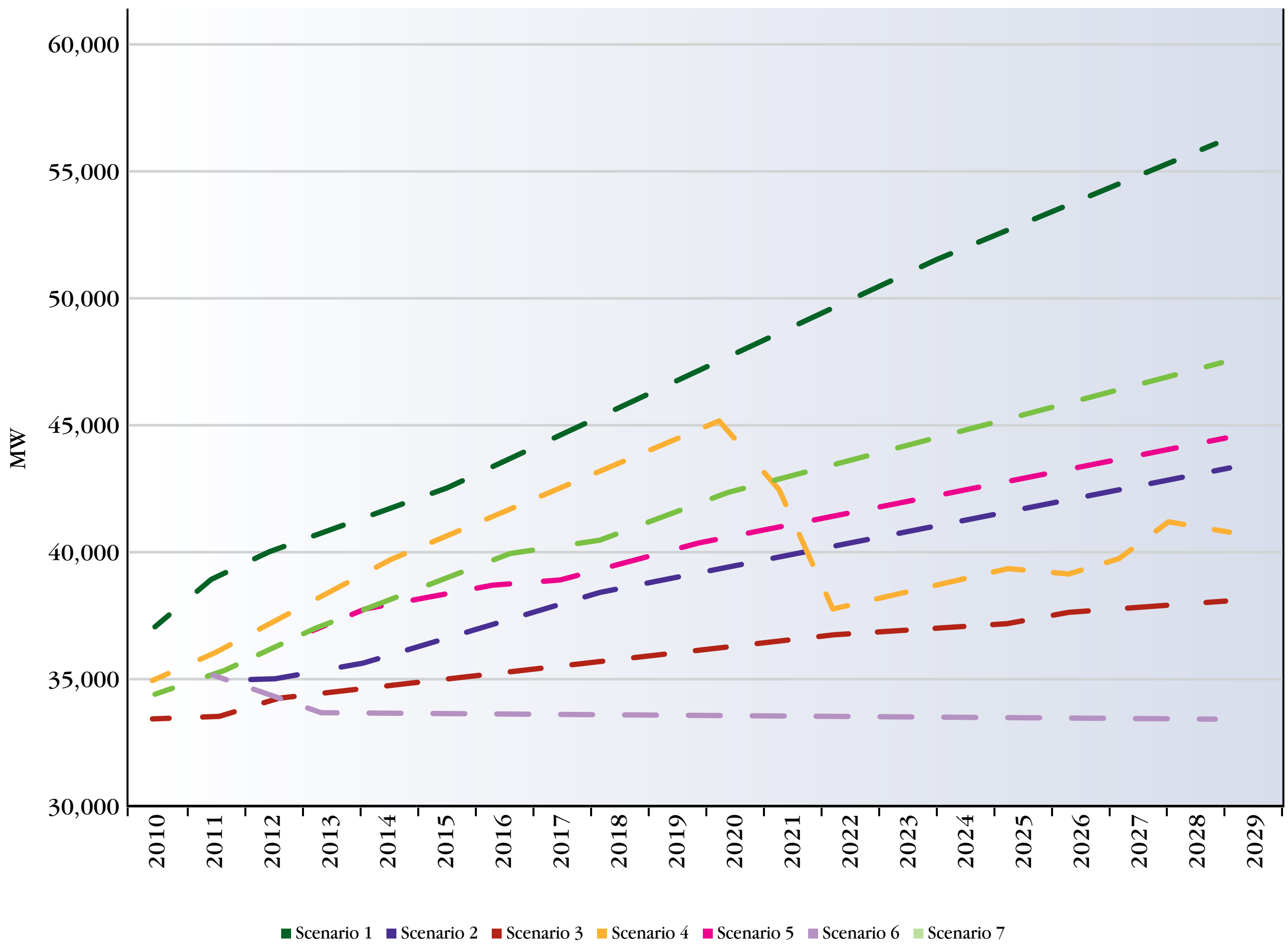
6 Resource Plan Results

6.1 Firm Requirements and Capacity Shortfall

A brief overview of the capacity needs studied in the IRP is presented in Chapter 3 for the IRP baseline case (see Section 3.3 and Figure 3-7). This section will review the capacity shortfall identified in each of the five planning strategies to set the context for the review of the expansion plans produced by evaluating each of these strategies across the seven scenarios.

As discussed in Chapter 5, each of the scenarios describes a different plausible future in which TVA may have to operate. The key attributes of each scenario are translated into a forecast of firm requirements (demand plus reserves) that is used to identify the resulting capacity shortfall that will determine the overall need for power and drive the selection of resources in the capacity planning model. Figure 6-1 contains the firm requirements forecasts for all seven scenarios:

Figure 6-1 – Firm Requirements by Scenario



Firm requirements are greatest in Scenario 1 (the highest load growth scenario) and lowest in Scenario 6 (growth in this scenario is flat to slightly negative). The remaining scenarios fall within this bandwidth and generally display a smooth growth trend, with the exception of Scenario 4 (the game-changing technology scenario). Scenario 4 contains a dramatic drop in load in 2021 to reflect the rapid commercialization of alternative technologies.

The shape of the firm requirements curves will influence the type and timing of resource additions in the strategies, especially in Scenario 4 where the dramatic drop in load will tend to reduce or eliminate resource additions in the later years of the planning study. The timing of any additional resources is also a function of the existing system capacity (see Chapter 1) and the impact of the defined model inputs for each strategy (defined model inputs are discussed in Section 5.3). Figure 6-2 summarizes the range of the capacity shortfall by the end of the study period (negative capacity shortfalls indicate a surplus). The range of the capacity gap in this figure is based on the maximum shortfall as computed in Scenario 1 and the minimum shortfall (surplus) as computed in Scenario 6.

Figure 6-2 – Range of Capacity Gaps by Strategy

Strategy	Max Capacity Gap (MW)	Min Capacity Gap (MW)
A	18,000	(4,800)
B	20,000	(3,000)
C	17,000	(6,000)
D	19,000	(4,000)
E	18,000	(5,000)

This range of capacity shortfalls will produce a wide range of expansion plans across the 35 portfolios developed in the IRP study.

6.2 Expansion Plans

As discussed in the previous chapter, TVA's capacity optimization analysis will solve for the best plan (least cost defined as the plan with the lowest present value of revenue requirements) based on the amount and timing of the capacity shortfall. This section presents a review of the portfolios produced by each of the planning strategies. These portfolios will be presented graphically as cumulative capacity additions by resource type. In order to display the portfolios from a given strategy for all seven scenarios, the results are shown in five-year increments over the study period.

Figures 6-3 through 6-7 present the 35 portfolios in the IRP study grouped by strategy. The results shown for Strategy A (Figure 6-3) indicate that expansion is virtually all purchased power, consistent with the attributes of that strategy. The general pattern of the amount of resource additions is also consistent with the assumptions that define each of the scenarios:

- The largest amount of resource additions will occur in Scenario 1.
- Scenario 7 (the Spring 2010 Baseline scenario) requires an average amount of new resources over the study period.

- Scenario 3 and Scenario 6 will have the least amount of resource additions – in fact, in most cases Scenario 6 will not require any new resources.
- Small amounts of new resources are added in Scenarios 2 and 5.
- In Scenario 4, no resources are added after 2020, consistent with the dramatic drop in load beginning in 2021.

Referring to Figure 6-3, the expansion plan for Strategy A also shows resources other than purchased power being added during the study period. These charts (as shown in Figures 6-3 through 6-7) reflect the contributions from TVA Board approved projects that are part of the expansion plan (the addition of the second unit at the Watts Bar nuclear plant and the combined cycle plant at the John Sevier site), as well as the impacts of the defined model inputs (particularly the capacity associated with the renewable resource portfolios and the avoided capacity value from EEDR). Figure 6-8, on page 110, shows the range of capacity additions by type across all the strategies.

Figure 6-3 – Limited Change in Current Resource Portfolio (Strategy A) Capacity Additions by Scenario

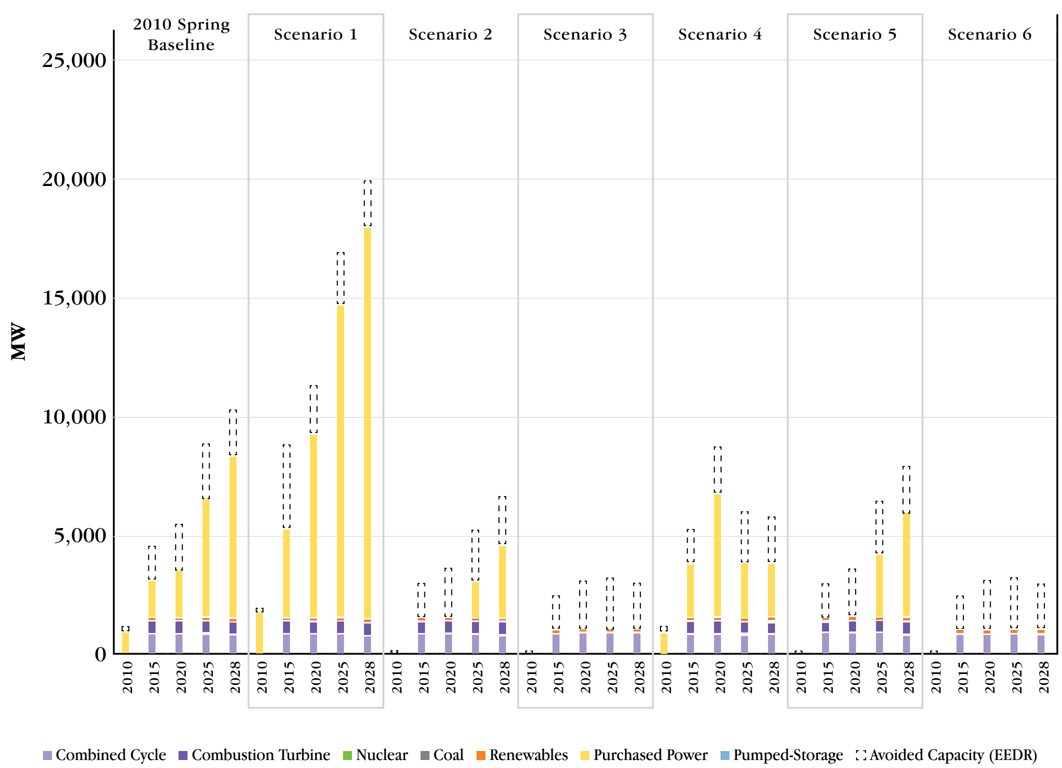


Figure 6-4 – Baseline Plan Resource Portfolio (Strategy B) Capacity Additions by Scenario

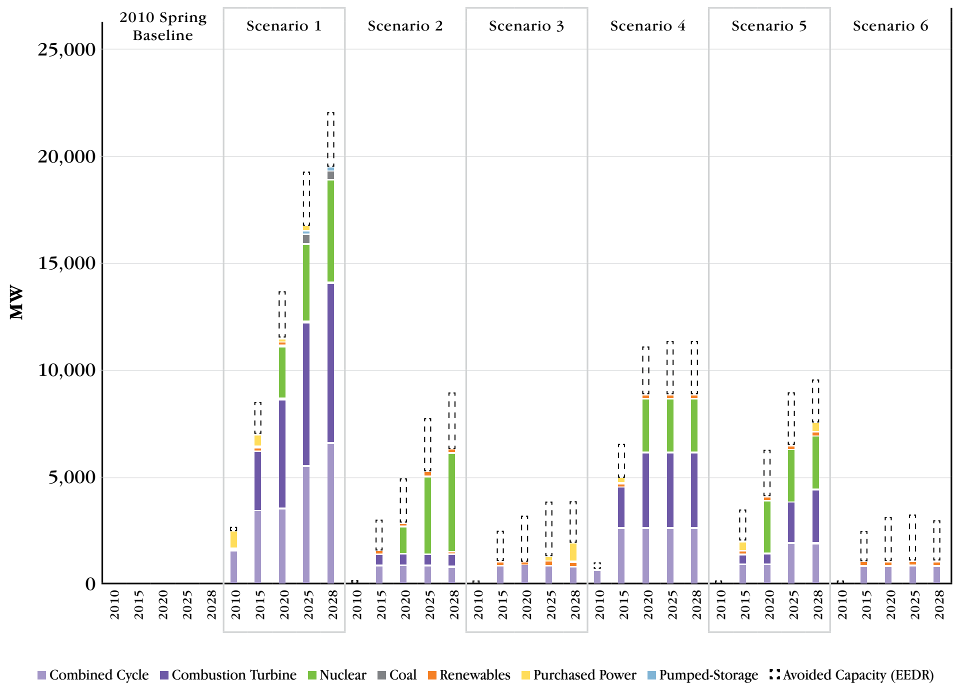


Figure 6-5 – Diversity Focused Resource Portfolio (Strategy C) Capacity Additions by Scenario

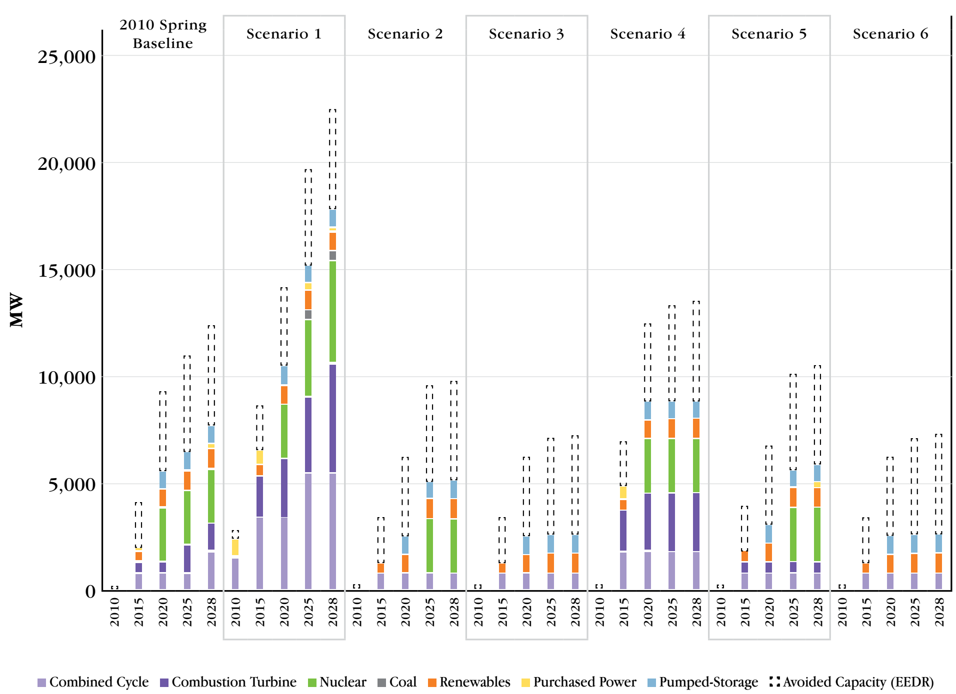


Figure 6-6 – Nuclear Focused Resource Portfolio (Strategy D) Capacity Additions by Scenario

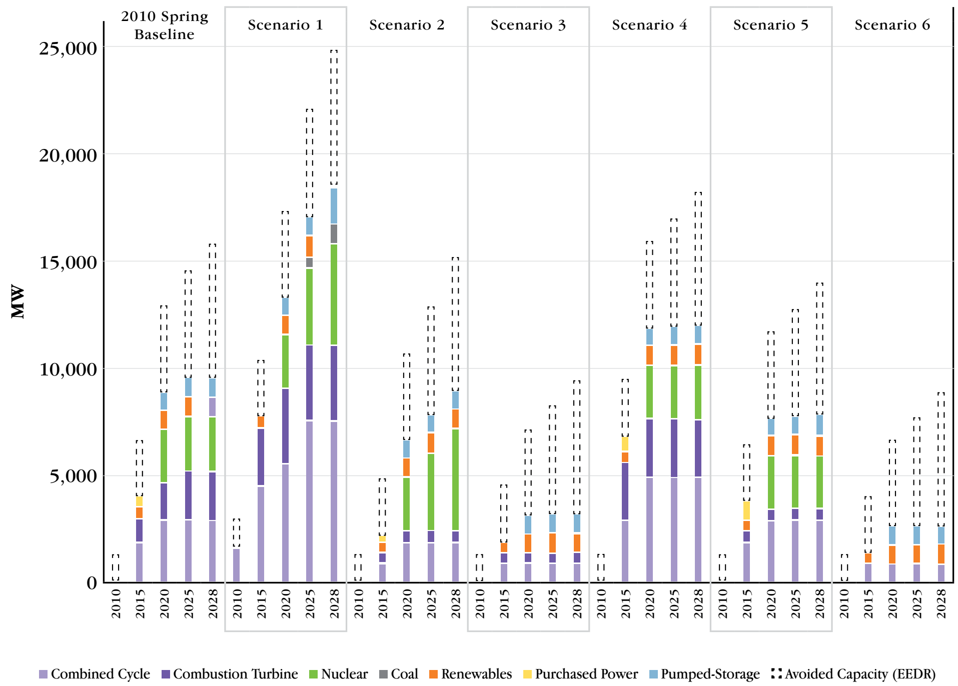


Figure 6-7 – EEDR and Renewables Focused Resource Portfolio (Strategy E) Capacity Additions by Scenario

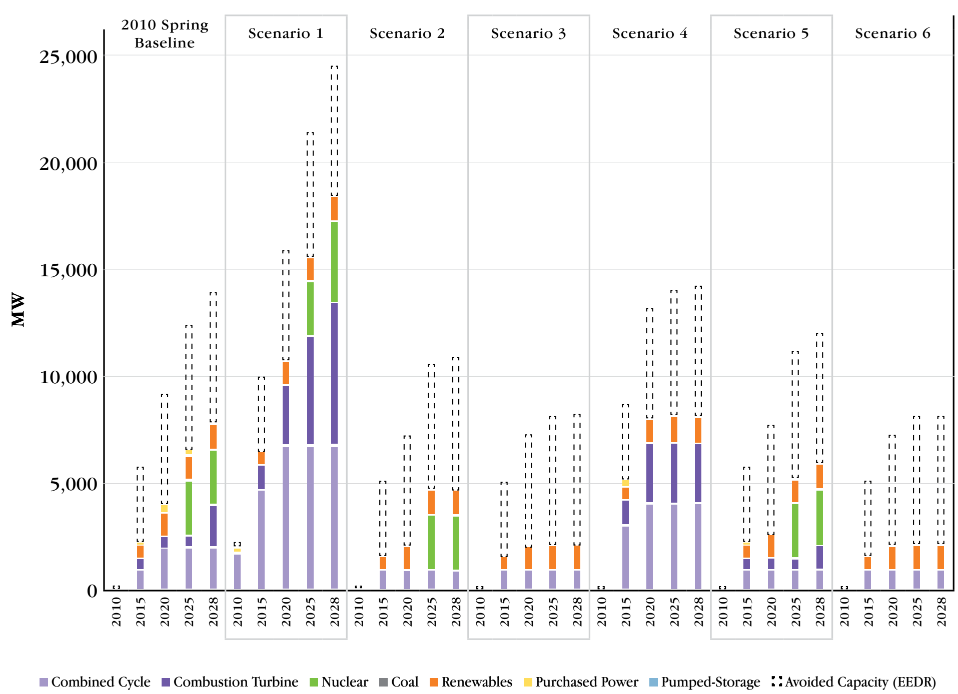


Figure 6-8 – Capacity Additions by 2029

Type	Minimum (MW)[2]	Maximum (MW)[3]
Nuclear	0	4,754(4)
Combustion Turbine	0	8,092 (11)
Combine Cycle	0	6,700 (7)
IGCC	0	934 (2)
SCPC	0	800 (1)
Avoided Capacity (EEDR)[4]	1,905	6,361
Renewables[4]	160	1,157
Pumped-storage[4]	0	850
Fossil Layups[4]	0	7,000

Notes:

1 – Values shown are for dependable capacity at the summer peak. Nameplate capacity of renewables range from 1,300 to 3,500 MW

2 – Minimums exclude Board-approved projects (WBN 2, JSFCC, and Lagoon Creek)

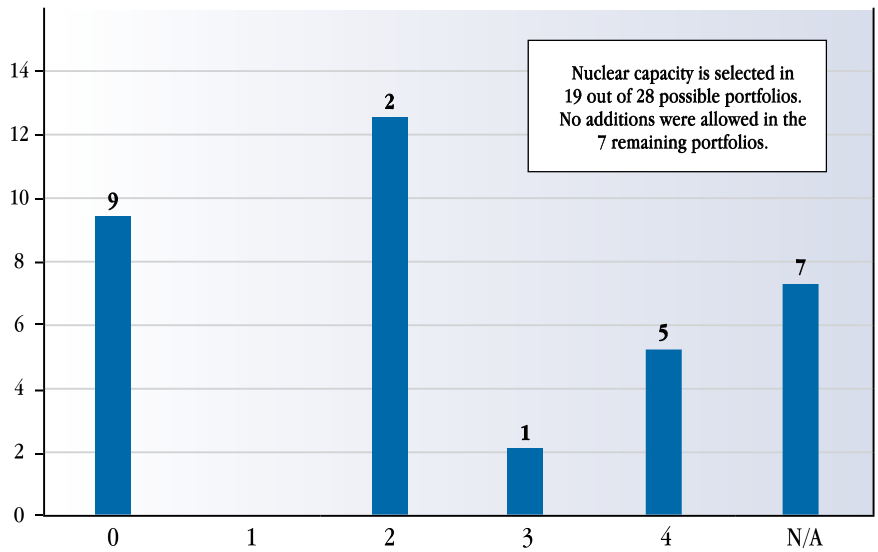
3 – Number of units shown in ( )

4 – Defined model input

To provide an alternative view of the expansion plan results, a set of histograms was developed that presents data on frequency of selection for key resource types across the 35 portfolios. Figures 6-9 through 6-12 are plots of the number of portfolios that contain a certain number of nuclear, coal, combined cycle or combustion turbine units.

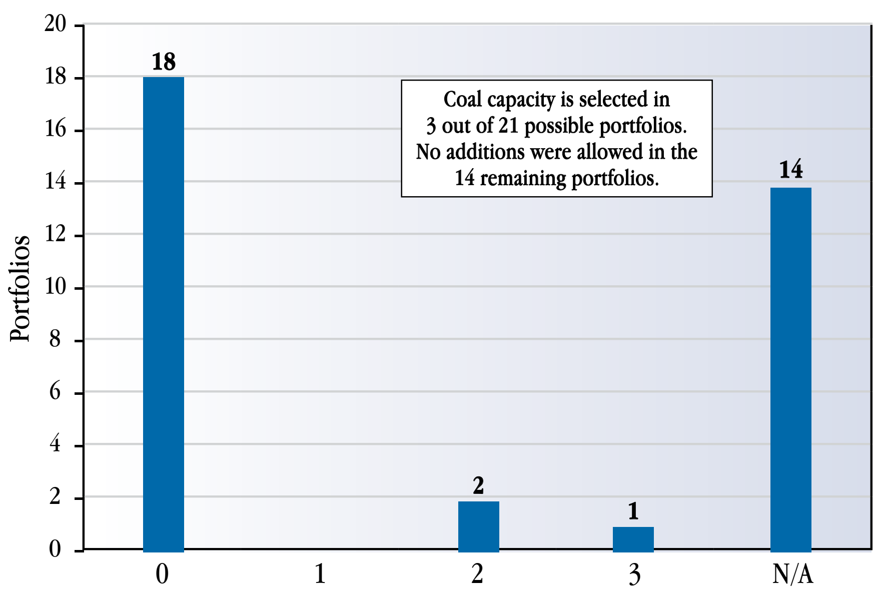
Nuclear capacity beyond Watts Bar 2 is prominent throughout analysis results, as shown in Figure 6-9. At least two nuclear units (and up to four) are added in 19 of 28 possible portfolios, and the first nuclear unit is added between 2018 and 2022. Nuclear was not selected for portfolios in scenarios with nearly flat load growth, and in one strategy nuclear was not a permitted resource option.

Figure 6-9 – Number of Nuclear Units Added



Coal capacity additions are very infrequent (see Figure 6-10). Integrated Gasification Combined Cycle (IGCC) units with carbon capture were selected after 2025 in just 3 of 21 possible portfolios. Supercritical Pulverized Coal (SCPC) with carbon capture was added in only 1 of 21 possible portfolios, and two strategies do not permit additional coal-fired units at all by design.

Figure 6-10 – Number of Coal Units Added



Combined cycle capacity added ranged from 0–6,700 MW (7 units) as shown in Figure 6-11 (potential acquisitions of IPP projects are included in the capacity additions shown). No combined cycle capacity was selected in 13 of 28 possible portfolios. As illustrated in Figure 6-12, on the following page, combustion turbine capacity additions ranged from 0–8,000 MW (11 units), and the majority of portfolios that selected combustion turbine capacity added just a single unit. Natural gas capacity (CT/CC) was not selected for portfolios in scenarios with nearly flat load growth or scenarios with the largest avoided capacity from EEDR.

Figure 6-11 – Number of Combined Cycle Units Added

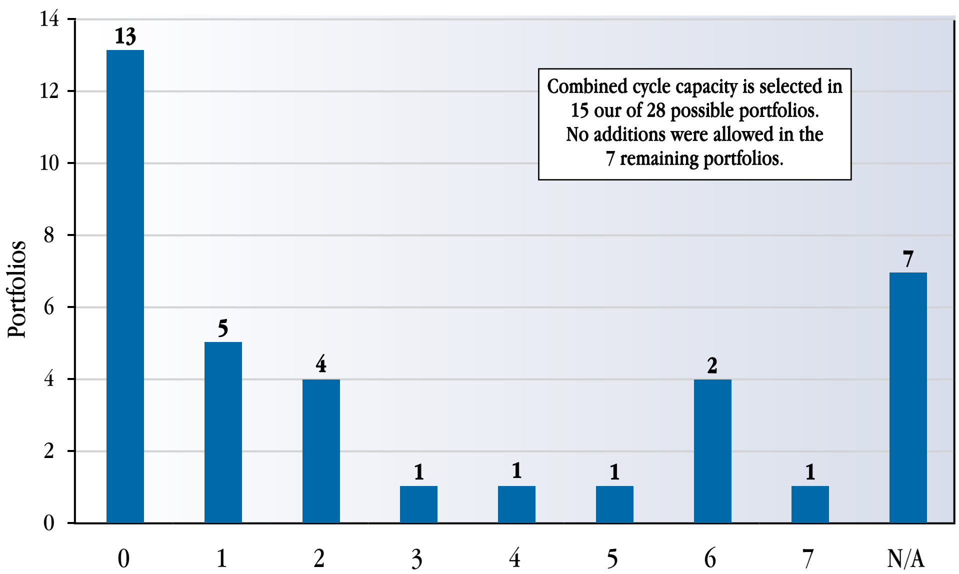
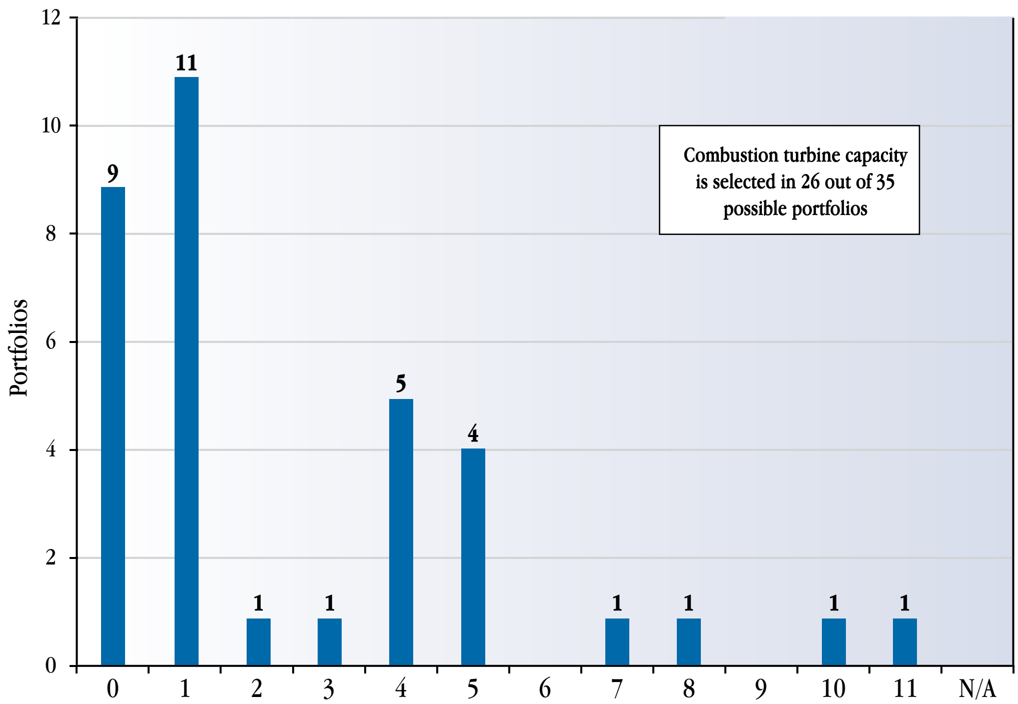


Figure 6-12 – Number of Combustion Turbine Units Added



6.3 System Energy Mix

Figure 6-13 lists the maximum and minimum percentage contributions to total energy production by type in 2025. Values represent the highest/lowest percentages for each type and are not from a single portfolio.

Figure 6-13 – Range of Energy Production by Type in 2025 (GWh)

Type	Minimum	Maximum
Combined Cycle	0%	13%
Combustion Turbine	0%	3%
Nuclear	27%	47%
Coal	24%	47%
Renewables	2%	8%
EEDR (savings)	2%	11%

Nuclear and coal have the greatest swings in percentage contribution to total energy. Nuclear actually overtakes coal and produces the greatest percentage of total energy in the majority of scenario/planning strategy combinations (Strategy A is an exception and coal remains the largest energy producer in that strategy).

6.4 Plan Cost and Risk

A comparison of the expected value of PVRR by scenario is shown in Figure 6-14. Scenario 1 results in the highest value of PVRR, while the lowest PVRR values are in Scenario 6. Within each scenario, Strategy D generally produces the highest cost portfolios due to the larger amount of fossil layup capacity that must be replaced by new resources. Strategy A results in the next highest cost set of portfolios, caused primarily by the higher level of coal-fired capacity in that strategy that is in turn exposed to more CO_2 compliance costs. Strategy C produces the lowest PVRR values in six of the seven scenarios.

Figure 6-14 – Expected Value of PVRR by Scenario

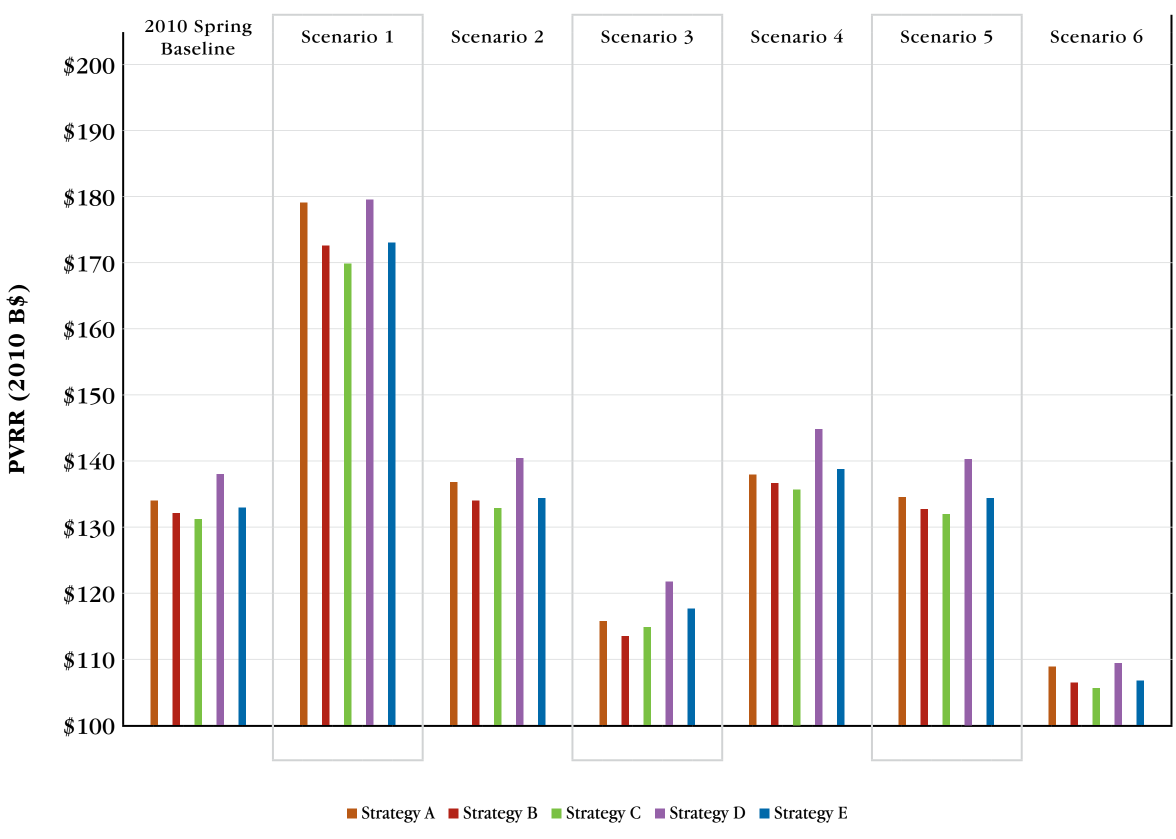
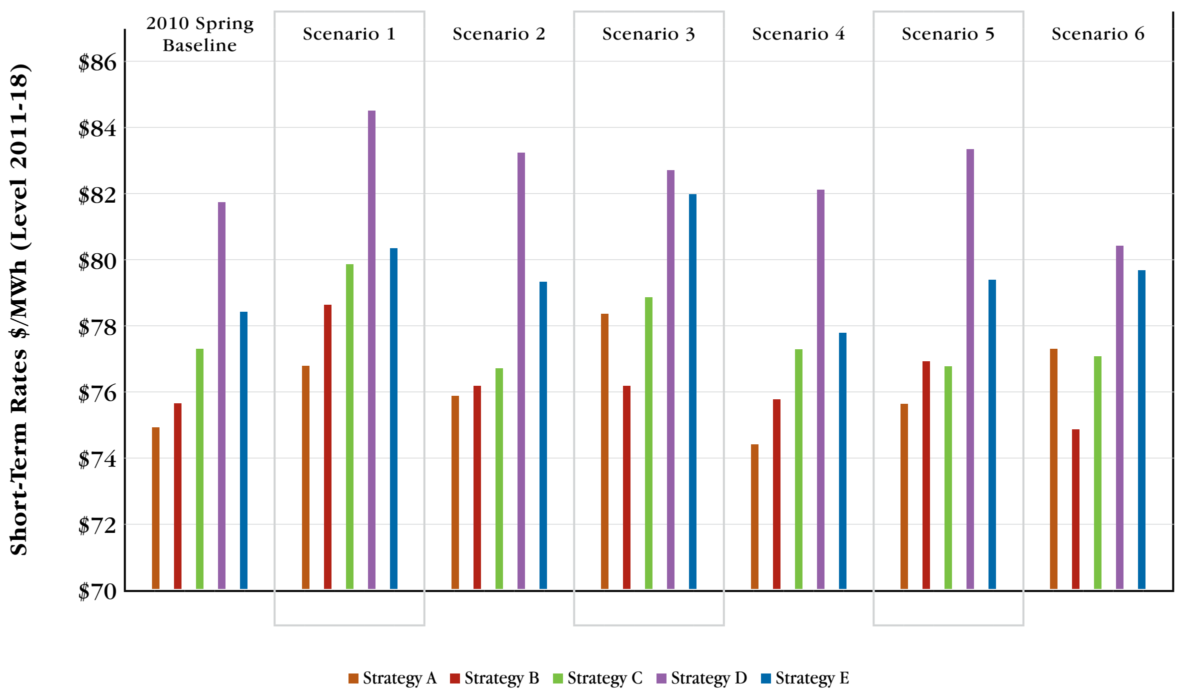


Figure 6-15 presents the short-term rate impacts (average system costs) by scenario. The strategy with the highest expected value of short-term rates is Strategy D because this strategy has the most new capacity additions in the 2011–2018 period. Strategy A has the lowest short-term rate values in five of the seven scenarios because no new capacity is added in any portfolios in that strategy; the exceptions (Scenario 3 and Scenario 6) are the result of higher CO_2 compliance costs driving up the cost of the coal-heavy portfolios in Strategy A in those scenarios.

Figure 6-15 – Expected Values for Short-Term Rates by Scenario



Figures 6-16 and 6-17, on the following page, compare the two risk metrics for the planning strategies. In general, lower ratios indicate less risky portfolios based on the probability distributions of the portfolio PVRR values. The relative relationship across the scenarios for both the risk ratio and the risk/benefit ratio are consistent: the highest values occur in Scenario 1; the risk ratio is lowest in Scenario 3; and the risk/benefit ratio is lowest in Scenario 6. In both cases, these low values are primarily caused by the much lower load forecasts in those scenarios that result in lower PVRR values with narrower probability distributions. Strategy A has the highest risk profile (represents the most risky strategy) in five of seven scenarios caused by the retention of coal-fired capacity; and Strategy C is the least risky strategy in six of the seven scenarios due to the generally balanced resource mix in the portfolios produced in that strategy.

Figure 6-16 – PVRR Risk Ratio by Scenario

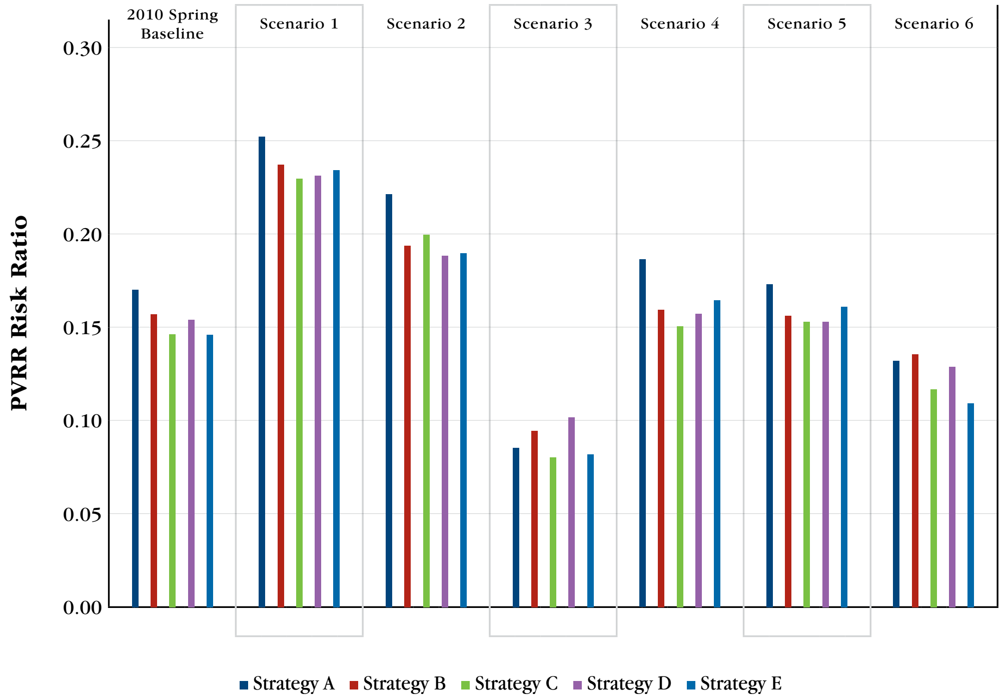
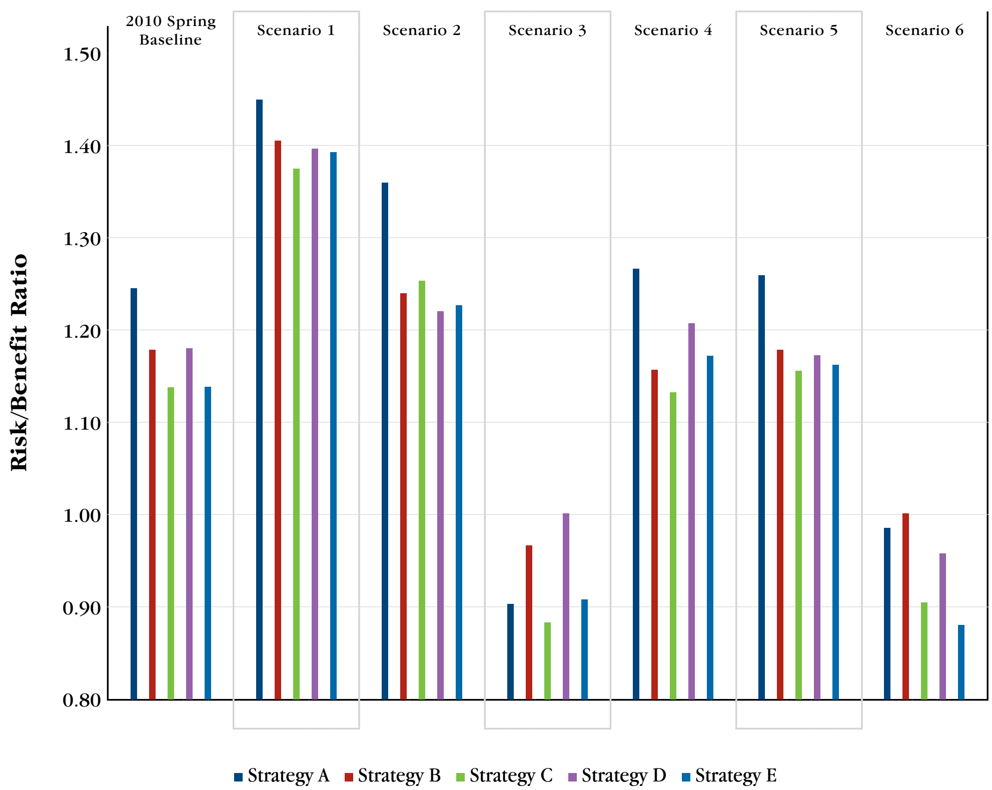


Figure 6-17 – PVRR Risk Benefit by Scenario



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7 Recommended Strategies

7.1 Overview of the Selection Process

The process for ranking and identifying preferred planning strategies is discussed in Chapter 5. Briefly, that process involves five steps:

1. Planning strategies are scored (based on cost and risk metrics) and ranked.
2. Strategic metrics are added to the ranking metrics to complete the scorecard for the top ranked strategies.
3. Selected strategies are released for public comment in the draft report and associated draft EIS.
4. Additional analysis is conducted and the strategies are refreshed and rescored. Final rankings are determined, and a short list is submitted to the TVA Board for approval of a preferred planning strategy.
5. Based on the strategy selected, an implementing portfolio (20-year resource plan) will be identified as the basis for annual capacity planning studies.

The ranking of each strategy is based on the expected values of the cost and risk metrics generated using the stochastic analysis method described in more detail in Chapter 5. The expected values are translated into a score, and the scores across all seven scenarios are combined to produce a total strategy score. Strategies are ranked based on total score from highest to lowest, and a subset of strategies is selected for further consideration based on scores and other strategic considerations.

7.2 Scorecard Results

Scorecards are generated by translating the expected values from the modeling results into a standardized score that can be summed across the scenarios for each planning strategy. Figure 7-1 summarizes the expected values of PVRR, Short Term Rates, Average of Risk/Benefits and Average of Risk computed for the five planning strategies in each of the seven scenarios, resulting in values for the 35 portfolios:

Figure 7-1 – Ranking Metrics Worksheet

		Scenarios							
	Strategy	1	2	3	4	5	6	7	**Average**
Average of PVRR (2010 B $)	A	180	137	116	138	135	109	134	**136**
	B	173	134	114	137	133	107	133	**133**
	C	170	133	115	136	133	106	131	**132**
	D	180	141	121	145	141	110	139	**140**
	E	173	135	118	139	135	108	134	**135**
Average of S.T. Rates $/MWh (level 2011-18)	A	76.82	75.92	78.42	74.47	75.75	77.31	74.97	**76.24**
	B	78.67	76.22	76.22	75.88	77.04	74.91	75.72	**76.38**
	C	79.95	76.73	78.93	77.25	76.99	77.11	77.35	**77.76**
	D	84.61	83.31	82.78	82.19	83.50	80.44	81.80	**82.66**
	E	80.41	79.39	82.05	77.91	79.40	79.82	78.52	**79.64**
Average of Risk/Benefit	A	1.45	1.36	0.91	1.27	1.26	0.99	1.25	**1.21**
	B	1.41	1.24	0.97	1.16	1.18	1.00	1.18	**1.16**
	C	1.38	1.28	0.89	1.13	1.16	0.91	1.14	**1.13**
	D	1.40	1.22	1.00	1.21	1.17	0.96	1.18	**1.16**
	E	1.40	1.23	0.91	1.17	1.16	0.89	1.14	**1.13**
Average of Risk	A	0.25	0.22	0.09	0.19	0.18	0.13	0.17	**0.18**
	B	0.24	0.20	0.10	0.16	0.16	0.14	0.16	**0.16**
	C	0.23	0.20	0.08	0.15	0.16	0.12	0.15	**0.16**
	D	0.23	0.19	0.10	0.16	0.16	0.13	0.16	**0.16**
	E	0.24	0.19	0.08	0.17	0.16	0.11	0.15	**0.16**

Applying the procedure described in Chapter 5 for translating actual values into color-coded scores, a scorecard can be produced for each of the five planning strategies. In the figure below, planning Strategy A is used to demonstrate how scores are computed and summed to produce the total ranking score:

Figure 7-2 – Planning Strategy A – Limited Change in Current Resource Portfolio

Planning Strategy A – Limited Change in Current Resource Portfolio

	RANKING METRICS				
Scenarios	PVRR	Short-Term Rate Impact	Risk/Benefit	Risk	Ranking Metric Score
1	93.87	100.00	95.07	91.26	94.82
2	95.76	99.25	90.32	85.74	93.61
3	98.28	95.78	98.39	94.38	96.84
4	97.49	100.00	88.75	77.41	92.42
5	97.09	99.85	91.73	87.21	94.81
6	94.14	93.66	90.08	80.82	90.51
Baseline	96.74	100.00	90.59	85.43	94.15
				Total Ranking Metric Score:	657.15

Total Ranking Metric Score=Sum of Ranking Metrics Scores for all seven scenarios

Ranking Metric Score=65%*(65%*PVRR + 35%*ST Rate) + 35%*(35%*Risk/Benefit + 65%*Risk)
=65%*(65%*97.09 + 35%*99.85) + 35%*(35%*91.73 + 65%*87.21)=94.81

Legend

Better

Scorecards for the remaining four strategies are shown in the following figures:

Figure 7-3 – Planning Strategy B – Baseline Plan Resource Portfolio

	RANKING METRICS				
Scenarios	PVRR	Short-Term Rate Impact	Risk/ Benefit	Risk	Total Plan Score
1	97.71	97.59	98.40	97.34	97.68
2	97.76	98.85	100.00	99.98	98.79
3	99.61	98.70	91.37	83.79	94.79
4	98.38	98.11	98.25	93.79	97.26
5	98.44	98.14	98.61	98.94	98.51
6	96.55	96.96	88.56	78.46	91.55
Baseline	98.01	99.01	96.50	94.26	97.20
				Total Ranking Metric Score:	**675.78**

Legend
Better

Figure 7-4 – Planning Strategy C – Diversity Focused Resource Portfolio

	RANKING METRICS				
Scenarios	PVRR	Short-Term Rate Impact	Risk/ Benefit	Risk	Total Plan Score
1	100.00	97.48	100.00	100.00	99.43
2	99.58	100.00	96.20	96.17	98.49
3	100.00	97.13	100.00	100.00	99.35
4	100.00	97.94	100.00	100.00	99.53
5	100.00	100.00	100.00	100.00	100.00
6	98.59	96.09	98.19	93.22	96.75
Baseline	100.00	98.71	100.00	100.00	99.71
				Total Ranking Metric Score:	**693.25**

Legend
Better

Figure 7-5 – Planning Strategy D – Nuclear Focused Resource Portfolio

	RANKING METRICS				
Scenarios	PVRR	Short-Term Rate Impact	Risk/ Benefit	Risk	Total Plan Score
1	97.40	97.54	96.41	96.81	97.18
2	97.90	98.51	99.04	98.90	98.40
3	99.41	100.00	81.31	69.12	90.43
4	97.40	97.97	90.14	92.05	95.42
5	97.86	98.47	96.57	92.60	96.64
6	100.00	100.00	89.16	78.46	93.77
Baseline	98.56	99.79	92.15	91.33	96.41
				Total Ranking Metric Score:	**668.26**

Legend	
	Better

Figure 7-6 – Planning Strategy E – EEDR and Renewables Focused Resource Portfolio

	RANKING METRICS				
Scenarios	PVRR	Short-Term Rate Impact	Risk/ Benefit	Risk	Total Plan Score
1	99.43	99.21	97.82	96.78	98.58
2	100.00	99.22	99.79	100.00	99.80
3	99.15	96.03	95.91	97.73	97.72
4	99.45	99.58	95.32	89.57	96.73
5	99.83	99.50	98.87	99.47	99.56
6	99.16	95.61	100.00	100.00	98.64
Baseline	99.68	99.77	98.98	98.96	99.45
				Total Ranking Metric Score:	**690.47**

Legend	
	Better

As discussed in Chapter 5, the scores assigned to each strategy (and the associated color coding) are done within a given scenario. To properly interpret the scoring for each strategy, the values for each individual ranking metric in all five strategies are compared within a particular plausible scenario.

7.3 Initial Ranking of Strategies

Detailed descriptions of strategies were introduced in Chapter 5. Figure 7-7 shows the rank order of the five planning strategies based on the total ranking metrics score (the total strategy scores range from 657–693 out of a possible 700 points).

Figure 7-7 Planning Strategy Ranking Order

Rank	Planning Strategy	Preliminary Observations
1	C – Diversity Focused Resource Portfolio	- Performs the best against PVRR and risk metrics - Near the median for short-term rates
2	E – EEDR and Renewables Focused Resource Portfolio	- Near the median for short-term rates - Performs near the best for PVRR
3	B – Baseline Plan Resource Portfolio	- Ranks near the median for PVRR, short-term rates and risk
4	D – Nuclear Focused Resource Portfolio	- Ranks below the median for PVRR, rates and risk
5	A – Limited Change in Current Resource Portfolio	- Performs the worst on PVRR and risk - Ranks the best for short-term rates in some scenarios

A key element of a “no-regrets” strategy is that a portfolio performs relatively well in all scenarios, and not just the base case scenario. Using the initial planning results, Strategy C is the top ranked planning strategy on the basis of the Total Ranking Metric Score, even though the separation between this strategy and Strategy E is not statistically significant. Strategy C represents an attempt to define a balanced approach to the resource mix and performs best in five of the seven scenarios for Total Plan Score, performs second best in another, and third in just one scenario. Based on the Ranking Metrics, this implies that Strategy C is the most robust in many possible futures. Looking at individual ranking metrics, Strategy C is the top performer for PVRR and both risk metrics. It performs reasonably well on short-term rates, but it is not the best strategy in that category.

The second best planning strategy (based on Total Ranking Metric Score) is Strategy E. As with Strategy C, this strategy represents an expanded commitment to cleaner resource options, especially EEDR and renewable energy options. The strategy performs well in all four of the ranking metrics and performs best in two of the seven scenarios for Total Plan Score. The metrics scores are sufficiently high to result in a total strategy score that is very close to Strategy C, indicating that in this initial planning phase, the combination of greater utilization of EEDR and renewable sources, when combined with a higher level of assumed fossil layups, would appear to perform almost as well as the balanced approach represented by Strategy C.

The third best planning strategy is Strategy B. This strategy represents a "business as usual" approach that does not significantly deviate from existing portfolio mixes over the long-term horizon. This strategy performs reasonably well with scores in the four ranking metrics that are in the middle of the range for each metric but does not rank number one in any of the scenarios studied. This observation, when combined with the separation in the scores between Strategy B and the strategies in the top tier, indicates that this approach should not be retained as a preferred strategy for purposes of further analyzing the IRP.

Strategy A and Strategy D are in the lower tier of the total strategy scores and do not appear to represent options that offer preferable planning approaches. These two strategies represent approaches that tend to define the boundary conditions within which the other strategy results can be placed. Strategy A is an approach that includes retention of all existing fossil capacity (with a high level of clean air capital and maintenance spending) and heavy reliance on the market. The scorecard for this strategy shows it to be the worst performer in most metrics for most scenarios, except for the short-term rate metric where it performs quite well. Strategy D is characterized by the largest level of fossil layups that necessitate the most new capacity additions, resulting in poor strategy scores across the scenarios, although this strategy does outperform Strategy A.

7.3.1 Sensitivity Cases

In addition to the initial 35 portfolios developed from the five planning strategies, TVA has also performed certain sensitivity analyses that focus on key assumptions in those strategies based on review of the scorecard results. In the draft report, this sensitivity analysis consists of four cases involving Strategy C and Strategy E (the top ranked strategies based on the results to date). The characteristics of these sensitivity cases are shown in Figure 7-8.

Figure 7-8 – Sensitivity Characteristics

Sensitivity Description	Basis for Selection
C1 – Strategy C with pumped-storage hydro removed	Test for improvement in short-term rate impacts by removing defined model input for pumped-storage hydro unit
C2 – Same as Sensitivity C1 with no capacity additions prior to 2018	Test for improvements in short-term rate impacts by defining near-term capacity additions. Modeled after Strategy A, which performs the best on rates
E1 – Strategy E with greater (7,000 MW) fossil layups (same as Strategy D)	Test to see if largest values for EEDR, renewables, and fossil layups significantly improve the PVRR and short-term rate impacts of Strategy E
E2 – Strategy E with lower (2,500 MW) renewable portfolio (same as Strategy C)	Improve PVRR and short-term rates by using the lower renewable portfolio applied in Strategy C

When these additional strategies are evaluated using the same ranking metrics applied to the original set of five planning strategies, a new rank order of strategies is established, as shown in Figure 7-9 (scores now range from 655–689):

Figure 7-9 – Rank Order of Strategies

Rank	Planning Strategy
1	C1 – Strategy C without pumped-storage hydro
2	C – Diversity Focused Resource Portfolio
3	C2 – same as C1 with no capacity additions prior to 2018
4	E – EEDR and Renewables Focused Resource Portfolio
5	E2 – Strategy E with greater fossil layups
6	E1 – Strategy E with lower renewable portfolio
7	B – Baseline Plan Resource Portfolio
8	D – Nuclear Focused Resource Portfolio
9	A – Limited Change in Current Resource Portfolio

Sensitivity C1 is a slight improvement over planning Strategy C and now has the highest-ranking metric score. Sensitivity C2 is slightly lower than strategy C. The stability of Strategy C as attributes changed represents a noteworthy attribute. Sensitivities E1 and E2 do not improve the results compared to Strategy E and will be removed from further consideration.

Based on the results of these initial sensitivities, and feedback already received from stakeholders, additional sensitivity cases will be studied following the release of the draft IRP report. Further case analysis may be suggested by public comments received on the draft IRP and associated EIS. The current listing of pending sensitivity cases is shown in Figure 7-10, on the following page. These cases will be discussed in the final IRP report.

Figure 7-10 – Summary Listing of Pending Sensitivity Cases

Sensitivity Description	Basis for Selection
Evaluate alternative fossil layup schedules in Strategy C	To test the impact of varying layup schedules are part of the evaluation of all defined model inputs
Evaluate impact of incremental or decremental levels of EEDR impacts in Strategy C	To identify the optimum level of EEDR given the other assumptions already set in this strategy
Evaluate impact of incremental or decremental levels of renewable resource additions in Strategy C	To identify the optimum level of renewables given the other assumptions already set in this strategy
Test deferral of nuclear expansion in Strategy C by postponing first year nuclear is allowed from 2018 to 2020	To evaluate the impact of nuclear addition timing on the short-term rate metric score for Strategy C
Test a gas-only expansion in Strategy C	To evaluate the impact to the ranking metrics, especially PVRR and short-term rates, for elimination of nuclear (and coal) as expansion alternatives
Evaluate impact on Strategy E if nuclear expansion is allowed earlier by advancing the first year nuclear is allowed from 2022 to 2018	To determine if the larger EEDR portfolio in this strategy would result in a deferral of nuclear expansion compared to Strategy C
Develop an additional scenario (#8) with attributes that match the most recent planning assumptions	Initial ranking metrics results need to be updated to include the latest assumptions
Evaluate an aggressive EEDR portfolio that targets 50% of the energy gap in selected scenarios beginning in 2015	To evaluate the impact on plan cost and risk for a more aggressive portfolio of EEDR programs (focused primarily on expanded EE benefits after 2015)

7.4 Other Strategic Considerations

In addition to the metrics used to establish the rank order of the planning strategies, TVA includes strategic metrics in the fully populated scorecard to help inform the final decision on a preferred planning strategy by recognizing other aspects of TVA's mission and potential environmental impacts. These strategic metrics include environmental and regional economic impact measures as discussed in Chapter 5. Note that for the economic impact measures, all of the IRP strategies were analyzed only for Scenario 1 and Scenario 6, the scenarios that were determined to define the upper and lower range of the impacts of the strategies within the scenario range.

Figure 7-11 below shows the strategic metrics for each of the five planning strategies.

Figure 7-11 – Strategic Metrics for Five Planning Strategies

Planning Strategy A

	Strategic Metrics				
	Environmental Stewardship			Economic Impact	
Scenarios	CO_2 Footprint	Water	Waste	Total Employment	Growth in Personal Income
1	○	◑	◑	0.1%	0.1%
2	○	◔	◔		
3	○	○	○		
4	○	◔	◑		
5	○	◔	◔		
6	○	○	◔	-0.4%	-0.4%
Baseline	○	◔	◑		

Planning Strategy D

	Strategic Metrics				
	Environmental Stewardship			Economic Impact	
Scenarios	CO_2 Footprint	Water	Waste	Total Employment	Growth in Personal Income
1	●	◕	●	1.2%	1.0%
2	●	◕	●		
3	●	●	●		
4	●	◕	●		
5	●	●	●		
6	◕	●	●	-0.1%	-0.2%
Baseline	●	●	●		

Planning Strategy B

	Strategic Metrics				
	Environmental Stewardship			Economic Impact	
Scenarios	CO_2 Footprint	Water	Waste	Total Employment	Growth in Personal Income
1	◔	○	○	1.0%	0.8%
2	◔	○	○		
3	◔	◔	◔		
4	◔	○	○		
5	◔	○	○		
6	◔	◔	○	-0.3%	-0.3%
Baseline	◔	○	○		

Planning Strategy E

	Strategic Metrics				
	Environmental Stewardship			Economic Impact	
Scenarios	CO_2 Footprint	Water	Waste	Total Employment	Growth in Personal Income
1	◕	●	◕	0.8%	0.6%
2	◕	●	◕		
3	◕	◕	◕		
4	◑	●	◕		
5	◕	◕	◕		
6	●	◕	◕	0.3%	0.2%
Baseline	◕	◕	◕		

Planning Strategy C

	Strategic Metrics				
	Environmental Stewardship			Economic Impact	
Scenarios	CO_2 Footprint	Water	Waste	Total Employment	Growth in Personal Income
1	◑	◔	◔	0.9%	0.6%
2	◑	◑	◑		
3	◑	◑	◑		
4	◕	◑	◔		
5	◑	◑	◑		
6	◑	◑	◑	0.2%	0.1%
Baseline	◑	◑	◔		

Legend	
●	Better
◕	↑
◑	
◔	
○	

Results of the CO_2 metric show Strategy D has the best performance (lowest emissions), followed by Strategy E, C, B and A. Each strategy shows a declining rate of emissions, and the variance between each strategy is quite low since all fossil units that remain in service will receive environmental controls. It should be remembered that all five strategies would be fully compliant with all applicable air emission regulations. Results for the other air emissions trends can be found in Appendix A. Results of the water metric show Strategy D has the best performance, followed by Strategy E, C, A and B. Additional information and calculations can be found in Appendix A.

Results of the waste metric show Strategy D has the best performance, followed by Strategy E, C, A and B. Additional information and calculations can be found in Appendix A.

Based on these preliminary results, planning Strategies D and E have the best relative performance across the environmental stewardship metrics. Strategy C is average to slightly above average, and Strategies A and B have the lowest relative performance.

For the economic impact metrics, Strategy A is the worst performer. Strategies B, C, D and E had more comparable results, within a few tenths of a percent difference from the impacts computed for the reference case (Strategy B in Scenario 7). Strategies C and E have very similar impacts, performing above the reference case in the long term under both Scenarios 1 and 6.

Along with the strategic metrics, innovations that enable the utilization of key technologies identified in the planning strategies have been identified and summarized in the figure below. Figure 7-12 identifies which of the five planning strategies would be impacted by each of the innovations.

Figure 7-12 – Technology Innovation

Technology Innovation	Description	A	B	C	D	E
Smart Grid Technologies	Advancements in this area are necessary to fully realize the EEDR benefits included in certain planning strategies.		X	X	X	X
Transmission Design & Infrastructure	Improvements in transmission system devices to manage power flows and advancement in dc line technologies will be needed to facilitate power transfers and the import of additional wind-sourced power.			X	X	X
Advanced Energy Storage	More research is needed to improve the design of pumped-storage hydro (PSH) and identify new storage technologies that might offer advantages similar PSH.			X	X	X
Small Modular Nuclear Reactors	This technology may offer some flexibility for siting and operating nuclear capacity in those strategies that include a reliance on new nuclear capacity later in the planning period.		X	X	X	X
Advanced Emission Controls for Coal-Fired Units	To enable full use of coal-fired resources, advances in emission controls (especially carbon capture and sequestration) are needed to achieve a more balanced long-term generation portfolio.	X	X	X		

TVA will closely monitor and may invest in these and other technology innovations during the planning period. The particular technology innovations that are necessary to implement the preferred planning strategy will likely shift as more information becomes available about each technology area and as power supply needs change.

In addition to the PVRR risk metrics discussed in Chapter 5, there are other risks that should be considered when evaluating the merits of alternative strategies. The financial risk measures included in the ranking metrics portion of the planning strategy scorecard may indirectly account for some of these risks, but only in part. Examples of these broader risk considerations include:

- The ability of EEDR programs to stimulate distributor/customer participation and deliver forecasted energy savings and demand reductions: Planning strategies with higher EEDR targets will have a greater exposure to this risk.
- The availability and deliverability of natural gas: There is finite capacity in the existing natural gas infrastructure. Risks of being limited by deliverability and availability will likely increase as natural gas generation capacity is increased.
- The ability to achieve schedule targets for licensing/permitting, developing and constructing new generation capacity: Risks of meeting schedule targets will likely increase as the number and complexity of construction projects increase. In addition, projects with more extensive licensing/permitting requirements may have greater exposure to schedule risk.
- The timely build-out of transmission infrastructure to support future resources: This is a particular concern with projects that may require transmission expansion outside of the TVA system, such as power purchase agreements for wind energy. Risks will likely increase as the amount of construction required increases and if that construction is undertaken by entities other than TVA.

The list above is not intended to be exhaustive. It provides examples of other strategic components that will be considered, along with the results of analysis and public input, as TVA identifies its preferred planning strategy. TVA encourages those commenting on the IRP to provide information about and their views on these other risks.

7.5 Recommended Strategies

Based on the preliminary results, TVA plans to retain the top three ranked planning strategies for further analysis. Strategies C, E and B will be subjected to additional analysis and sensitivity testing in an effort to determine improved combinations of planning attributes. Composite strategies may also be developed by combining attributes of one or more of the strategies. A recommended planning strategy will be identified from these strategies.

This information, along with appropriate evaluations that may be proposed in public comments on the draft report, will be included in the final IRP scheduled for completion in spring 2011. The strategies and recommendations contained within the final IRP will be presented to the TVA Board for approval of a preferred planning strategy.

7.6 Implementing Portfolio

Implementing portfolios (20-year resource plan) will be identified as part of the evaluation that will be done between the release of the draft and final IRP. In this draft report, a broad set of portfolios has been identified that corresponds to the three planning strategies retained for further analysis.

Four representative resource plans were selected from planning Strategies C, E and B; the 12 implementing portfolios for the draft IRP are shown in Figure 7-13. These portfolios describe a relatively broad set of resource plan options that will be subjected to additional analysis prior to completing the final IRP. Portfolios produced in Scenario 1 represent the most new resource additions, while those produced in Scenario 3 represent the least amount of new resources that could be added over the planning period.

Figure 7-13 – Implementing Portfolios

Year	Planning Strategy C				Planning Strategy E				Planning Strategy B			
	SC 1	SC 2	SC 3	SC 7	SC 1	SC 2	SC 3	SC 7	SC 1	SC 2	SC 3	SC 7
2010	PPA's & Acq				PPA's & Acq				PPA's & Acq			
2011												
2012	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC
2013	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2
2014	CTa								CTa CT GL CT Ref			
2015	CT GL CT Ref CC			GL CT Ref CC	GL CT Ref CTa CC (2)			GL CT Ref CC	CT CC	GL CT Ref		GL CT Ref CTa
2016	CT				CT				CT			CT
2017									CT			CTa
2018	BLN1			BLN1	CT			CC	BLN1			BLN1
2019					CC				CT	BLN1		
2020	BLN2 PSH	PSH	PSH	BLN2 PSH	CC	PSH	PSH		BLN2			BLN2
2021	CT				CTa				CC	BLN2		
2022	CC	BLN1			BLN1	BLN1		BLN1	CT CC			CC
2023	CC				CT				CT			CT
2024	NUC	BLN2			BLN2	BLN2		BLN2	NUC			
2025	IGCC			CT	CT				IGCC	NUC		CT
2026	NUC				CT			CT	NUC			
2027	CT			CC	CT				CT	NUC		CT
2028	CT				NUC			CTa	CC			
2029	IGCC CTa	NUC		CTa	CT			CTa	IGCC CTa	CTa	CTa	CC

Defined Model Inputs	
Fossil Layups	3,252 MW by 2015
Renewable Firm Capacity	953 MW by 2029
	8,791 GWh by 2029
EEDR	4,638 MW by 2029
	14,032 GWh by 2029

Defined Model Inputs	
Fossil Layups	4,730 MW by 2015
Renewable Firm Capacity	1,157 MW by 2029
	12,251 GWh by 2029
EEDR	6,043 MW by 2029
	16,455 GWh by 2029

Defined Model Inputs	
Fossil Layups	2,415 MW by 2015
Renewable Firm Capacity	160 MW by 2029
	4,231 GWh by 2029
EEDR	2,520 MW by 2029
	7,276 GWh by 2029

Key:
PPA's & Acq = purchased power agreements, including potential acquisition of third-party-owned projects (primarily combined cycle technology)
JSF CC = the combined cycle unit to be sited at the John Sevier plant (Board approved project, currently under development)
WBN2 = Watts Bar Unit 2 (Board approved project, currently under development)
GL CT Ref = the proposed refurbishment of the existing Gleason CT units
CC = combined cycle
CT/CTa = combustion turbines
PSH = pumped-storage hydro
BLN1/BLN2 = Bellefonte Units 1 & 2
NUC = nuclear unit
IGCC = integrated gasification combined cycle (coal technology)

Key observations about these 12 portfolios include:

- The first non-Board approved new unit addition is in 2014 or 2015 in 6 of the 12 portfolios.
- EEDR avoided capacity benefit is as much as 6000 MW by the end of the planning period; renewables can provide up to an additional 1100 MW of capacity.

- New nuclear capacity is added in 9 of the 12 portfolios; the earliest in-service year for new nuclear is 2018.
- In addition to nuclear, additions are primarily combustion turbine units, with combined cycle capacity added late in the planning period or in the high growth scenarios.
- IGCC capacity is added late in the planning period in two of the high load growth scenarios.

The 35 portfolios that are produced by evaluating each planning strategy in each scenario of the IRP can be found in Appendix C. A recommendation about the implementing portfolio (or portfolios) will be made after additional analysis for the final IRP report has been completed.

7.7 Conclusion and Next Steps

TVA has renewed its vision to help lead the Tennessee Valley region and the nation toward a cleaner and more secure energy future, relying more on nuclear power and energy efficiency and relying less on coal. The publication of the draft IRP is a major milestone in the identification of TVA's long term planning approach to meet that vision. However, there are still many issues that need to be addressed prior to publication of the final IRP such as evaluation of feedback from the public comment period and other stakeholder concerns, evaluation of overall portfolio risks and execution of additional sensitivity analysis.

During the period of time between the publication of the draft IRP and the publication of the final IRP, TVA will continue to interact with stakeholder groups and the general public. In addition, analysis will continue with the goal of clearly refining multiple strategic options that TVA should consider for long-term implementation. This additional evaluation, along with stakeholder feedback, will be instrumental in identifying the recommended strategy from the short list (Strategies B, C and E), strategies resulting from sensitivities run from that list, or a composite of those strategies that balances the key aspects of TVA's mission.

The final IRP, along with the included recommended planning strategy, will be submitted to the TVA Board in Spring 2011. Using the information provided in the IRP, along with other input, the TVA Board is expected to approve a preferred long-term planning approach. This strategy will provide a recommended direction that retains the flexibility required to meet future power supply requirements and is in the best long-term interest of Valley residents.

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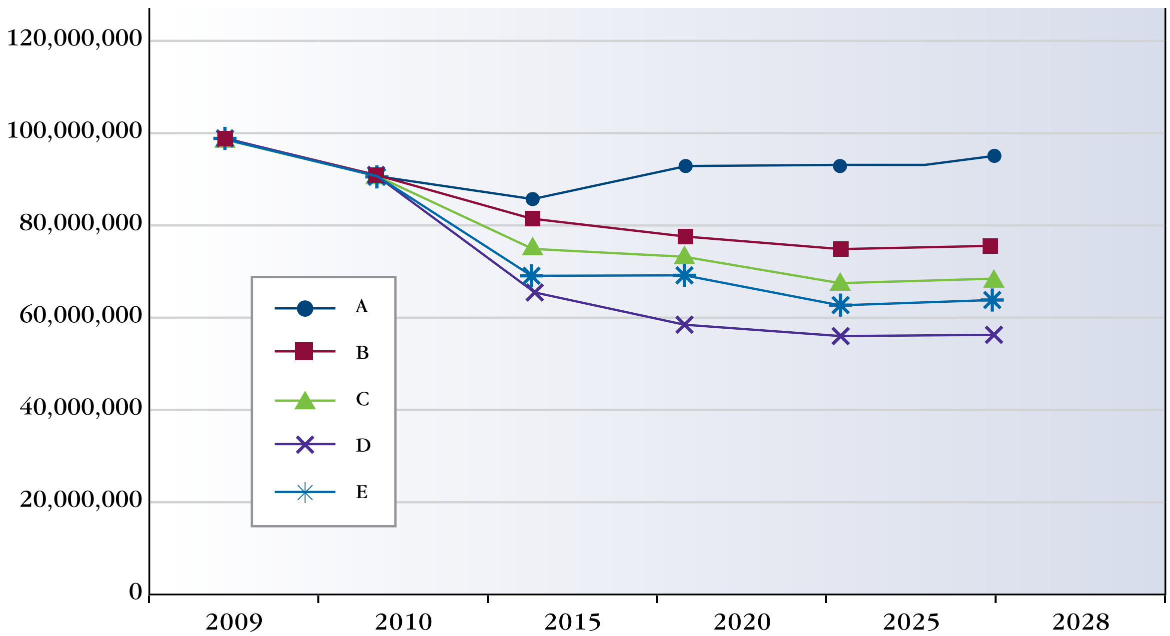
Appendix A – Method for Computed Environmental Impact Metrics

Air Impact Metric and Ranking

Model results provided data on the production of four emissions: carbon dioxide (CO_2), sulfur dioxides (SO_2), nitrogen oxides (NO_x) and mercury (Hg) by generation source (e.g. coal, lignite, etc.). It was suspected that evaluating the strategies on the basis of all four emissions would give the same results as just using CO_2 alone, but emission trend plots were developed to confirm this assumption. Emission trends were plotted against averaged, historic TVA generation data from 2007–2009 for coal and combustion turbines (CTs). The most recent three years were used to provide a better representation of average air emissions, as 2009 was a historically low year for air emissions due partly to the economic recession and decreased electricity demands. Historic mercury emissions for lignite sources were unavailable, so projected data for 2010 was used and added to the other totals.

Again using model results by generation sources for each of the cases, CO_2 emissions data from all emission sources were summed for selected spot years (five-year increments) 2010, 2015, 2020, 2025 and 2028. Then for each of these years, the CO_2 emissions for each strategy (A–E) were summed across all seven worlds – this gives a value for the total CO_2 emissions associated with each strategy. These totals were divided by seven to provide a representative average value for each spot year that could be compared to the 2007–2009 averaged historical data. These data were plotted to demonstrate how CO_2 emissions vary over time (see Figure A-1).

Figure A-1 – Tons CO_2 by Strategy



Similar calculations were also done for SO_2, NO_X, and Hg – figures are shown below.

Figure A-2 – Tons SO_2 by Strategy

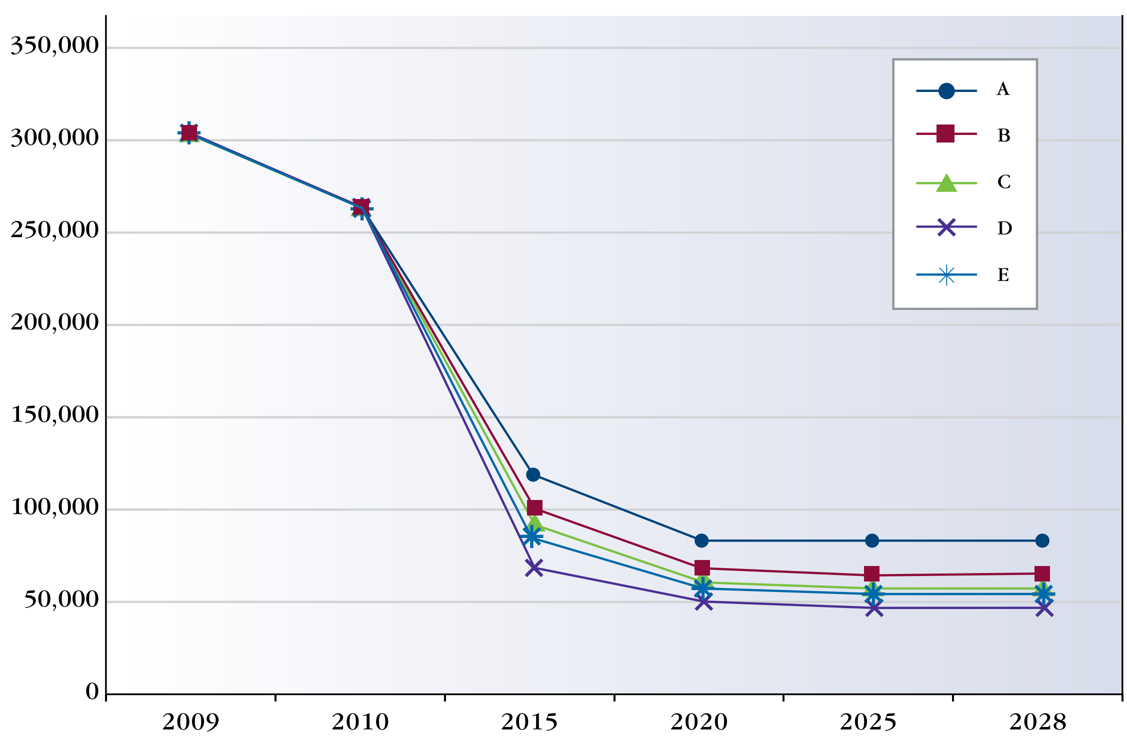


Figure A-3 – Tons NO_x by Strategy

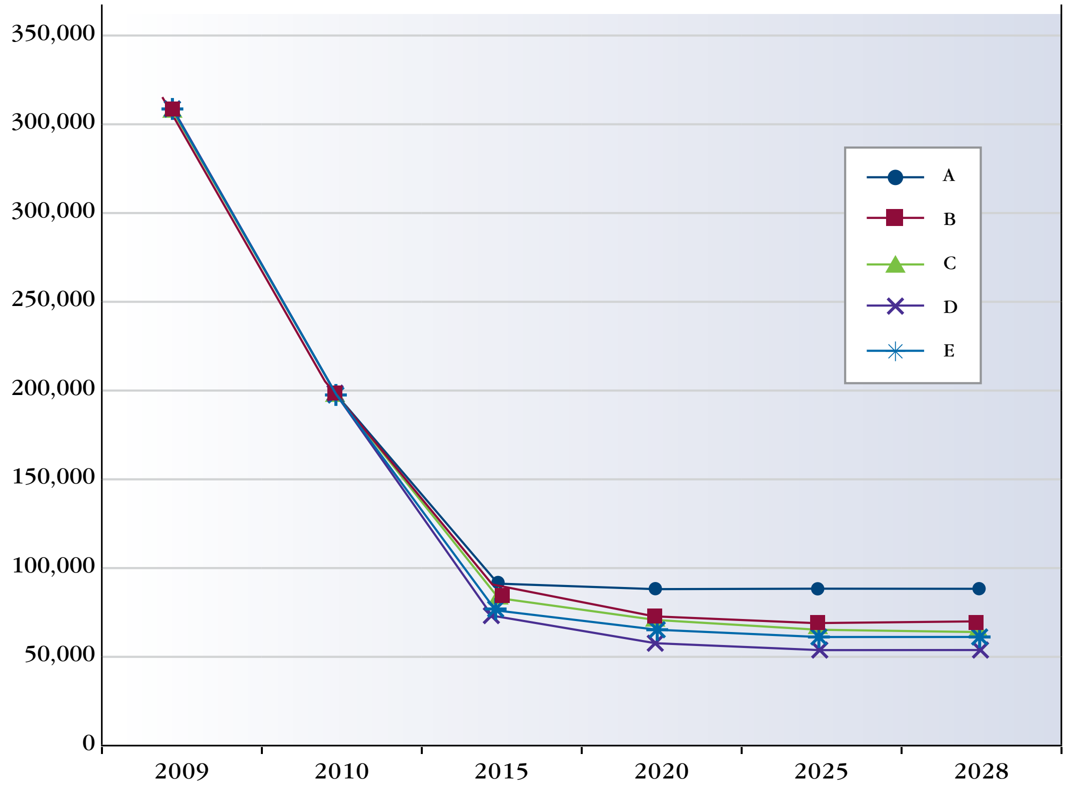
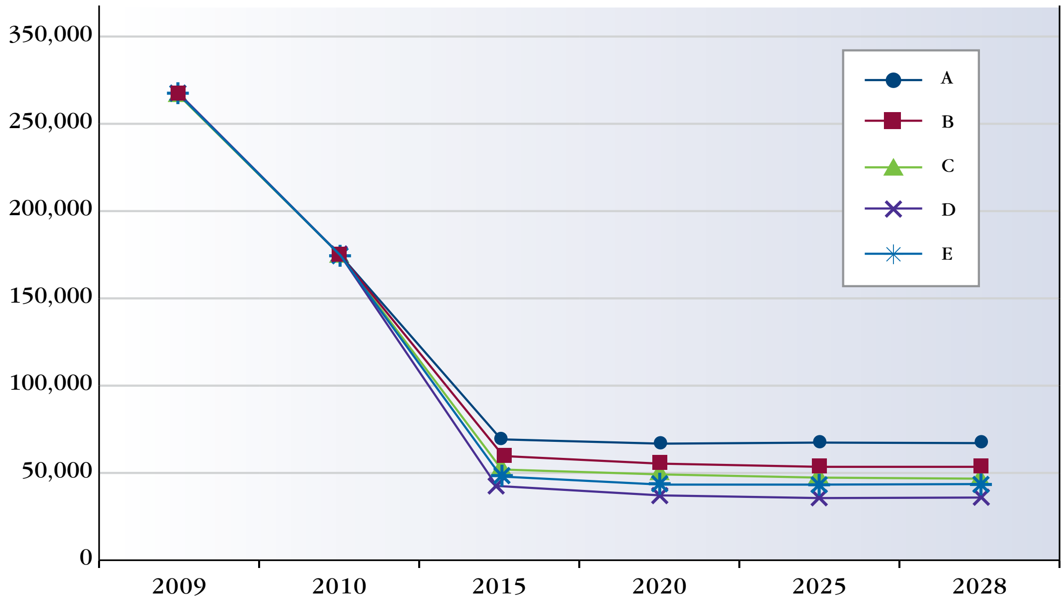


Figure A-4 – Lbs HG by Strategy



These plots show that, in general, all emissions decrease over time with the exception of CO_2 in Strategy A, which does not include any fossil layups. They also show that all five strategies result in similar performance in terms of reductions in emissions over the spot years, thus confirming that CO_2 is an appropriate proxy for the trend in all air emissions.

To further verify that all five strategies' performance on all four emissions give the same rankings, the total yearly emissions from all sources for each strategy across all seven worlds were summed for five spot years and used to rank the strategies for each emission. Figure A-5 shows the results of these rankings, again confirming that the CO_2 ranking alone gives the same information as using information on all four emissions.

Figure A-5 – Strategy Rankings for All Four Emissions

Strategy	SO_2	NO_X	Hg	CO_2
A	5	5	5	5
B	4	4	4	4
C	3	3	3	3
D	1	1	1	1
E	2	2	2	2

It should be noted that using CO_2 alone appears to penalize Strategy A since CO_2

emissions do not decline over the time period as the other emissions decline. This is due to the assumptions under Strategy A that no fossil plants are laid up but SO_2 and NO_x emission controls are installed.

Water Impact Metric and Ranking

The major way thermal generating plants impact water is by the amount of heat they reject to the environment. IRP strategies were evaluated on the basis of the BTUs delivered to the plants' condensers, which is where rejected heat is transferred. The calculation involves taking the generation sources shown in Figure A-6 and multiplying their generation (GWh) by heat rate (BTU/kWh) (with unit conversions) by a design factor for the specific generation technology.

Figure A-6 – Design Factors for Generation Sources

Generation Source	Design Factor
Coal	51%
Combined Cycle (CC)	11%
Future Integrated Gasification CC	27%
Future Super Critical Pulverized Coal (SCPC)	46%
Lignite	51%
Uranium	66%

The heat rejected to the environment (BTUs) is summed for all five spot years (2010, 2015, 2020, 2025, 2028) and all generation sources for each case. For each world (1–7), the strategies (A–E) are compared to each other and ranked. A preferred strategy is the most robust (i.e., performs the best across all seven worlds). Therefore, we sum the rankings of each strategy in each world, and re-rank them on the basis of their total score. A strategy that performed the best in each of the seven worlds would have a total score of 7 (1 x 7), and a strategy that performed the worst in all seven worlds would have a score of 35 (5 x 7). The total scores and associated final ranking is shown in Figure A-7 below.

Figure A-7 – Final Strategy Water Impact Ranking

Worlds	Strategy				
	A	B	C	D	E
1	3	5	4	2	1
2	4	5	3	2	1
3	5	4	3	1	2
4	4	5	3	2	1
5	4	5	3	1	2
6	5	4	3	1	2
7	4	5	3	1	2
Sum of Rankings	29	33	22	10	11
Final Ranking	4	5	3	1	2

Waste Calculations

The metric used to rank strategies in terms of their waste impact (coal and nuclear) is the cost of handling the waste generated—the assumption is that the costs of disposal, in accordance with all applicable regulations, is a proxy for the wastes' impacts on the environment. Handling costs are based on actual, historical TVA averages, expected future handling costs based on operations and transportation estimates.

Coal waste comes from two sources: coal burning and scrubber sludge. Coal waste for TVA plants was calculated using weighted coal ash and heated content (BTU/lb) values from 2009 historical data. The weighted averages are shown in Figures A-8 and A-9.

Figure A-8 – Weighted Ash Percentage

Year	Strategy				
	A	B	C	D	E
2010	8.19%	8.19%	8.19%	8.19%	8.19%
2015	8.19%	8.04%	7.91%	8.71%	8.15%
2020	8.19%	8.04%	7.91%	8.99%	8.15%
2025	8.19%	8.04%	7.91%	8.99%	8.15%
2028	8.19%	8.04%	7.91%	8.99%	8.15%

Figure A-9 – Weighted Heat Content (BTU/lb)

Year	Strategy				
	A	B	C	D	E
2010	11,033	11,033	11,033	11,033	11,033
2015	11,033	11,004	10,948	11,556	11,134
2020	11,033	11,004	10,948	11,809	11,134
2025	11,033	11,004	10,948	11,809	11,134
2028	11,033	11,004	10,948	11,809	11,134

For each strategy (A–E), from the model results, the fuel consumed (mmBTU) for TVA coal was multiplied by 1 million to get the units into BTUs, then multiplied by the coal fuel conversion values (from the weighted BTU/lb figure), and then multiplied by the percentage ash value (from the weighted ash figure). The product was then divided by 2000 to get an answer in tons. A handling cost ($/ton) is then applied to the calculation.

Coal waste from the lignite plant under contract to TVA was calculated based on fuel consumed (mmBTU), divided by 5,234 BTU/lb, multiplied by 14.64% ash content (based on Mississippi lignite source information), and divided by 2000 to get an answer in tons. A handling cost ($/ton) is then applied to the calculation.

Coal waste from future Integrated Gasification Combined Cycle (IGCC) was calculated by multiplying generation times 62lb/MWh (slag production) and divided by 2000 to get an answer in tons. Coal waste from future Super Critical Pulverized Coal (SCPC) was calculated by taking the fuel consumed (mmBTU), divided by 8,803 BTU/lb, multiplied by 4.83% ash content (average Powder River Basin coal values), and divided by 2000 to get an answer in tons. A handling cost ($/ton) is then applied to the calculation.

For 2010 scrubber waste, waste is calculated by taking fuel consumed (mmBTU), multiplied by 0.5 (about 50% of TVA generation is now scrubbed), times 11 lbs/mmBTU (average of TVA existing fleet). For future year calculations, it was assumed that all remaining TVA coal generation (based on fossil layup assumptions) are scrubbed. Waste is calculated by multiplying fuel consumed by 11 lbs/mmBTU. A handling cost ($/ton) is then applied to the calculation.

The combined coal and nuclear waste handling costs are used to rank all five scenarios. All fossil waste costs (including lignite and future base generation) and nuclear waste costs are summed for all five spot years (2010, 2015, 2020, 2025, 2028) and all generation sources for each case. For each world (1–7), the strategies (A–E) are compared to each other and ranked with the strategy having the lowest waste handling cost (ranked #1) and the strategy with the highest costs (ranked #7).

A preferred strategy is the most robust (i.e., it performs the best across all seven worlds). Therefore, we sum the rankings of each strategy in each world, and re-rank them on the basis of their total score. A strategy that performed the best in each of the seven worlds would have a total score of 7 (1 x 7) and a strategy that performed the worst in all seven worlds would have a score of 35 (5 x 7). The total scores and associated final ranking is shown in Figure A-10 below.

**Figure A-10 – Final Strategy Waste Impact Ranking
(Based on Total Coal and Nuclear Waste Disposal Costs)**

Worlds	Strategy				
	A	B	C	D	E
1	3	5	4	1	2
2	4	5	3	1	2
3	5	4	3	1	2
4	3	5	4	1	2
5	4	5	3	1	2
6	4	5	3	1	2
7	3	5	4	1	2
Total	26	34	24	7	14
Ranking	4	5	3	1	2

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Appendix B – Method for Computed Economic Impact Metrics

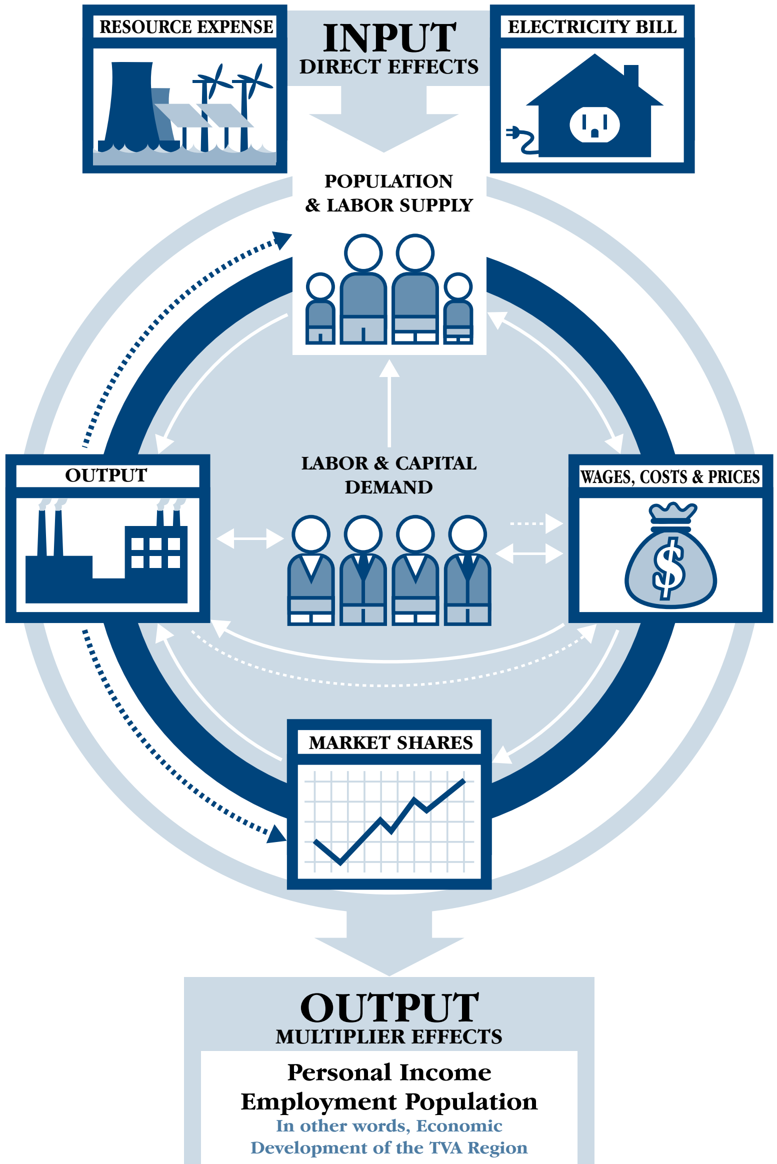
Regional Socioeconomic Impacts

Economic metrics are included to provide a general indication of the impact of each strategy on the general economic conditions in the TVA service area, represented by the change in total employment and personal income indicators as compared to the impacts that would be realized under Strategy B (Baseline Plan Resource Portfolio) in Scenario 7. The process used is, on the whole, the same as has been used at TVA for programmatic region-wide EIS dating back to the 1979-80 PURPA study. It is also, in general, the same as that used by other models/studies. This process is described below.

Process

As shown in Figure B-1, on the following page, direct expenses by TVA in the region on labor, equipment and materials stimulate economic activity. At the same time, the costs of electricity to customers (the bills customers pay, including savings from energy efficiency) take away from the income that customers could use to buy goods and services in the region.

Figure B-1 – Input/Output Effects



These "direct effects" are input into a regional economic model, which captures the interactions within the regional economy – the so-called multiplier effect. TVA uses a Regional Economic Models, Inc. (REMI) model of the economies of the TVA region and surrounding areas. This model maps the Valley's economic structure, its inter-industry linkages, and responses to TVA rate and customer cost changes, including from energy efficiency. Along with the TVA region economy relations, the model also captures interactions with areas outside the Valley, such as for coal purchases from outside the Valley.

The analysis includes data on direct TVA expenditures in terms of applicable payrolls, material and supply purchases, and fuel costs for all energy resource options that comprise a particular strategy for both construction and operations. It also includes data on TVA rates/total resource cost resulting from each strategy and savings to customer bills from energy efficiency/demand reduction programs.

Methodology

Annual construction expenses were entered into the regional economic model for each strategy/scenario analyzed. The model then calculated two types of indirect effects from construction expenses:

- The increase in goods manufactured in the Valley, as a result of purchasing materials and supplies in the region associated with a project.
- The additional income generated in the regional economy, resulting from spending by workers hired for the purpose of the construction activity.

The analysis of operations was similar to that for construction. Annual operations expense data for the strategy portfolio was entered into the economic model. Given fuel purchase patterns, most of these purchases came from outside the region and were entered into the analysis as expenses in areas outside the region.

The analysis also estimated the effects of cost differences among strategies. Differences in customer cost, or electric bills, add to or subtract from the spending capacity of customers and thus affect the amount of income/revenue available for other uses. Such income, when returned to the economy, generates additional economic growth. Estimates of annual total resource costs for each strategy, as well as net savings from energy efficiency/demand reduction programs to customers, were used to estimate net cost differences among strategies. These were used with the TVA regional economic model to compute the impacts.

All of the IRP strategies were analyzed for Scenario 1 and Scenario 6, the scenarios that were determined to define the upper and lower range of the impacts of the strategies within the scenario range. The factors discussed above were incorporated into the regional economic model for each strategy/scenario in order to measure the overall economic development effects for each strategy/scenario, including indirect effects. Overall, economic impacts are the net effect of both direct factors—resource expenses and customer electricity bills—as measured in terms of employment and income changes from the base case, Strategy B (Baseline Plan Resource Portfolio) in Scenario 7, due to both the direct and indirect economic impacts.

Findings

In terms of percent difference in the overall Valley economy as measured by both employment and income, the major finding is that there was no significant change (differences were around 1% or less) in both the short- and long-term for the range of strategies and scenarios. Although none of the strategies portrayed significant differences from the base case, there were differences in a relative sense as shown in Figure B-2 below.

As shown in the figure, Strategy A performed worse than any of the other strategies for the scenario range. Strategies B, C, D and E had more comparable results, within a few tenths of a percent difference. The impacts of Strategy B and Strategy D were very similar, performing better in the high growth Scenario 1 than C or E, but worse in the low growth Scenario 6 than C or E or the base case. This is consistent with strategies that lean towards building to meet load, versus C and E which lean towards conservation. Strategy C and Strategy E's impacts were very similar, performing above the base case in the long-term under both Scenario 1 and Scenario 6.

Figure B-2 – Final Summary Economic Impacts of IRP Cases

		Percent difference from IRP Base Case			
		Total Employment		Total Personal Income	
Stategy	Scenario	Average 2011-2028	Average 2011-2015	Average 2011-2028	Average 2011-2015
A	1	0.1%	-0.4%	0.1%	-0.2%
	6	-0.4%	-0.4%	-0.4%	-0.3%
B	1	1.0%	0.3%	0.8%	0.3%
	6	-0.3%	-0.4%	-0.3%	-0.3%
C	1	0.9%	0.2%	0.6%	0.2%
	6	0.2%	-0.2%	0.1%	-0.1%
D	1	1.2%	0.4%	1.0%	0.3%
	6	-0.1%	-0.4%	-0.2%	-0.4%
E	1	0.8%	0.0%	0.6%	0.0%
	6	0.3%	-0.1%	0.2%	-0.1%

Scenario

1 Economy Recover Dramatically
2 Environmental Focus is a National Priority
3 Prolonged Economic Malaise
4 Game-Changing Technology
5 Energy Independence
6 Carbon Legislation Creates Economic Downturn
7 Current Situation

Planning Strategy

A Limited Change in Current Resource Portfolio
B Baseline Plan Resource Portfolio
C Diversity Focused Resource Portfolio
D Nuclear Focused Resource Portfolio
E EEDR and Renewables Focused Resource Portfolio

Baseline is Scenario 7, Strategy B

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Appendix C – Expansion Plan Listing

Figure C-1 – Planning Strategy A – Limited Change in Current Portfolio

Year	Defined Model Inputs			Capacity Additions by Scenario						
	EEDR	Renewables	Fossil Layups	SC1	SC2	SC3	SC4	SC5	SC6	SC7
2010	246	35	-							
2011	408	48	-							
2012	421	137	-	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC
2013	666	155	-	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2
2014	1733	155	-							
2015	1434	160	-	GL CT Ref	GL CT Ref		GL CT Ref	GL CT Ref		GL CT Ref
2016	1557	160	-							
2017	1684	160	-							
2018	1812	160	-							
2019	1940	160	-							
2020	2051	160	-							
2021	2069	160	-							
2022	2014	160	-							
2023	2061	160	-							
2024	2131	160	-							
2025	2085	160	-							
2026	2226	160	-							
2027	2076	160	-							
2028	1980	160	-							
2029	1905	160	-							

Figure C-2 – Planning Strategy B – Baseline Plan Resource Portfolio

Year	Defined Model Inputs			Capacity Additions by Scenario						
	EEDR	Renewables	Fossil Layups	SC1	SC2	SC3	SC4	SC5	SC6	SC7
2010	229	35	-	PPA's & Acq			PPA's & Acq			
2011	385	48	(226)							
2012	384	137	(226)	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC
2013	610	155	(935)	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2
2014	1363	155	(935)	CTa CT GL CT Ref			CTa		GL CT Ref	
2015	1496	160	(2,415)	CT CC	GL CT Ref		GL CT Ref CT CC	GL CT Ref		GL CT Ref CTa
2016	1622	160	(2,415)	CT			CT			CT
2017	1751	160	(2,415)	CT			CT			CTa
2018	1881	160	(2,415)	BLN1			BLN1	BLN1		BLN1
2019	2012	160	(2,415)	CT	BLN1					
2020	2124	160	(2,415)	BLN2			BLN2	BLN2		BLN2
2021	2216	160	(2,415)	CC	BLN2					
2022	2294	160	(2,415)	CT CC				CTa		CC
2023	2362	160	(2,415)	CT				CTa		CT
2024	2429	160	(2,415)	NUC						
2025	2470	160	(2,415)	IGCC	NUC			CC		CT
2026	2495	160	(2,415)	NUC						
2027	2509	160	(2,415)	CT	NUC			CT		CT
2028	2516	160	(2,415)	CC						
2029	2520	160	(2,415)	IGCC, Cta	Cta	Cta		CT		CC

Key:

PPA's & Acq = purchased power agreements, including potential acquisition of third-party-owned projects (primarily combined cycle technology)

JSF CC = the combined cycle unit to be sited at the John Sevier plant (Board approved project, currently under development)

WBN2 = Watts Bar Unit 2 (Board approved project, currently under development)

GL CT Ref = the proposed refurbishment of the existing Gleason CT units

CC = combined cycle

CT/CTa = combustion turbines

PSH = pumped-storage hydro

BLN1/BLN2 = Bellefonte Units 1 & 2

NUC = nuclear unit

IGCC = integrated gasification combined cycle (coal technology)

Figure C-3 – Planning Strategy C – Diversity Focused Resource Portfolio

Year	Defined Model Inputs			Capacity Additions by Scenario						
	EEDR	Renewables	Fossil Layups	SC1	SC2	SC3	SC4	SC5	SC6	SC7
2010	298	35	-	PPA's & Acq						
2011	389	48	(226)							
2012	770	145	(226)	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC
2013	1334	286	(935)	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2
2014	1596	44	(935)	CTa			CTa			
2015	2069	515	(3,252)	GL CT Ref CT CC			GL CT Ref CT CC	GL CT Ref		GL CT Ref CTa
2016	2537	528	(3,252)	CT			CT			
2017	2828	715	(3,252)							
2018	3116	768	(3,252)	BLN1			BLN1			BLN1
2019	3395	822	(3,252)							
2020	3627	883	(3,252)	BLN2 PSH	PSH	PSH	BLN2 PSH	PSH	PSH	BLN2 PSH
2021	3817	896	(3,252)	CT						
2022	3985	911	(3,252)	CC	BLN1			BLN1		
2023	4143	922	(3,252)	CC						
2024	4295	935	(3,252)	NUC	BLN2			BLN2		
2025	4412	942	(3,252)	IGCC						CT
2026	4502	947	(3,252)	NUC						
2027	4561	948	(3,252)	CT						CC
2028	4602	953	(3,252)	CT						
2029	4638	954	(3,252)	IGCC, Cta	NUC			CTa		CTa

Figure C-4 – Planning Strategy D – Nuclear Focused Resource Portfolio

Year	Defined Model Inputs			Capacity Additions by Scenario						
	EEDR	Renewables	Fossil Layups	SC1	SC2	SC3	SC4	SC5	SC6	SC7
2010	1300	35	-	PPA's & Acq						
2011	1126	48	(226)							
2012	1394	145	(226)	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC
2013	1795	286	(935)	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2
2014	2228	442	(935)	CTa		GL CT Ref	GL CT Ref CT CTa			
2015	2612	515	(5,718)	GL CT Ref CT(2) CC(2)	GL CT Ref		CT(2) CC(2)	GL CT Ref CC		GL CT Ref CTa(2) CC
2016	2846	528	(5,718)	CT			CC	CC		CC
2017	3104	715	(6,972)	CC	CC		CC			CTa
2018	3389	768	(6,972)	BLN1	BLN1		BLN1	BLN1		BLN1
2019	3704	822	(6,972)							
2020	3993	883	(6,972)	BLN2 PSH	BLN2 PSH	PSH	BLN2 PSH	BLN2 PSH	PSH	BLN2 PSH
2021	4092	896	(6,972)							
2022	4040	911	(6,972)	CC (2)						
2023	4042	922	(6,972)							CTa
2024	4303	935	(6,972)	NUC						
2025	4991	942	(6,972)	IGCC	NUC					
2026	5201	947	(6,972)	NUC						
2027	5711	948	(6,972)		NUC					
2028	6198	953	(6,972)	IGCC						
2029	6316	954	(6,972)	SCPC						

Key:
PPA's & Acq = purchased power agreements, including potential acquisition of third-party-owned projects (primarily combined cycle technology)
JSF CC = the combined cycle unit to be sited at the John Sevier plant (Board approved project, currently under development)
WBN2 = Watts Bar Unit 2 (Board approved project, currently under development)
GL CT Ref = the proposed refurbishment of the existing Gleason CT units
CC = combined cycle
CT/CTa = combustion turbines
PSH = pumped-storage hydro
BLN1/BLN2 = Bellefonte Units 1 & 2
NUC = nuclear unit
IGCC = integrated gasification combined cycle (coal technology)

Figure C-5 – Planning Strategy E - EEDR and Renewables Focused Portfolio

Year	Defined Model Inputs			Capacity Additions by Scenario						
	EEDR	Renewables	Fossil Layups	SC1	SC2	SC3	SC4	SC5	SC6	SC7
2010	34	35	-	PPA's & Acq						
2011	181	48	(226)							
2012	1136	178	(226)	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC
2013	1664	314	(935)	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2
2014	2431	493	(935)							
2015	3479	580	(4,730)	GL CT Ref CTa CC(2)			GL CT Ref CTa CC(2)	GL CT Ref		GL CT Ref CTa
2016	3843	616	(4,730)	CT			CT			
2017	4183	846	(4,730)							
2018	4504	921	(4,730)	CT			CT			CC
2019	4811	994	(4,730)	CC (2)						
2020	5074	1060	(4,730)	CC (2)			CC			
2021	5353	1074	(4,730)	CTa						
2022	5460	1094	(4,730)	BLN1	BLN1			BLN1		BLN1
2023	5599	1107	(4,730)	CT						
2024	5739	1124	(4,730)	BLN2	BLN2			BLN2		BLN2
2025	5815	1133	(4,730)	CT						
2026	5893	1142	(4,730)	CT						CT
2027	5961	1145	(4,730)	CT						
2028	6009	1154	(4,730)	NUC				CTa		CTa
2029	6043	1157	(4,730)	CT				CTa		CTa

Key:
PPA's & Acq = purchased power agreements, including potential acquisition of third-party-owned projects (primarily combined cycle technology)
JSF CC = the combined cycle unit to be sited at the John Sevier plant (Board approved project, currently under development)
WBN2 = Watts Bar Unit 2 (Board approved project, currently under development)
GL CT Ref = the proposed refurbishment of the existing Gleason CT units
CC = combined cycle
CT/CTa = combustion turbines
PSH = pumped-storage hydro
BLN1/BLN2 = Bellefonte Units 1 & 2
NUC = nuclear unit
IGCC = integrated gasification combined cycle (coal technology)

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